THE ARMOUR ENGINEER

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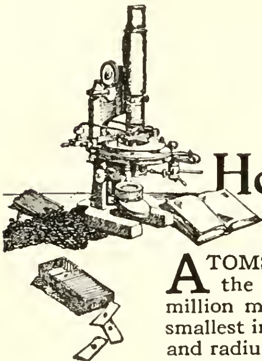

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BUILDING AND OPERATING A CIDER VINEGAR PLANT.

By John Joseph Schommer.

In the spring of 1917 I was asked to design and equip a plant for M. Steffen & Company, Chicago, Illinois, for the purpose of manufacturing cider vinegar. The plant had to be ready for manufacturing by autumn.

This resolved itself into the problem of securing the following:

Chicago site,
Site at the source of supply of apples,
Materials of construction,
Manufacturing equipment,
Labor.

The high cost of construction, the scarcity of labor, and the length of time required to build new buildings, disposed very quickly of my idea for a new plant·

The Chicago site had to be on a railroad line to facilitate cheap shipment of apples and cider stock from points outside of Chicago and, of course, finished goods from Chicago to other cities. It had also to be within easy hauling distance of the "down town" wholesale grocery houses.

Good buildings on railroad tracks were at a high premium and anything suitable involved too great a sacrifice of capital. Buildings badly needing repair and on railroad tracks near the central portion of the city were diligently searched for. Finally a one and a half story building of seventeen thousand square feet on Kinksbury Street, located on the St. Paul railroad track, was leased for a period of five years. The building was in bad condition. The following were necessary in order to place the property

in a manufacturing condition:

New sky lights,
Patching of brick walls,
Patching of wood walls,
Patching of roof,
Repairing of shipping platforms outside of building,
Division of inside into office space, shipping space, manufacturing, and storing parts,
Concrete piers for holding up large storage tanks,
Concrete washing tank ten by six by four feet deep,
And storage space for at least three cars of apples (one car of apples averages about 35,000 pounds).

Bids were asked for and the contract was let for $13,500.

A steam boiler was purchased second hand from a dismantled building on Pine Grove Ave. Its cost was $600.00. Its rated capacity was seventy pounds gauge. To install it and build a chimney cost $900,000 additional. The boiler furnished sufficient steam to run pumps, heat the plant, office, and necessary water for cleaning barrels, bottles, and tanks. The remodeled Chicago plant ready for the installation of equipment cost $15,000.00.

The procuring of equipment for quick delivery from the dealers of vinegar equipment was impossible. Six months to a year was the usual stock phrase used in promising machinery, tanks, generators, etc. The impending prohibition enforcement suggested that much material might be purchased from breweries forced out of business. A number of breweries were visited by me and much was bought at prices ridiculously low.

The following was purchased and installed at about one-fourth of the original estimate for new materials and was in splendid condition:

	Each
3—25,000 gals. storage tanks installed........	$460.00
4—15,000 " " " "	260.00
2— 7,000 " " " "	150.00
9— 3,000 " " " "	50.00

These tanks were of white wood, Washington fir, and cypress. The cypress is the best. The above was purchased from the Schoenhofen Brewing Company.

Three screw presses made by Boomer & Borchert Manufacturing Company were bought for $400.00. These were purchased from hard cider plants going out of business in Illinois and Michigan.

Four pumps were bought from the Blackmar Pump Company, Chicago. These pumps are acetic acid proof and are bronze lined. They are portable affairs, motor driven, and are placed on trucks so they may be hauled to any part of the plant.

Several hundred feet of hose of about three inches diameter was purchased. This is used for portable piping. It is used to pump sweet juice and vinegar from fermentors to storage tanks and generator room. Wood logging is often used for this purpose, but it is not as convenient as the portable hose. Vinegar pumped through iron pipes turns black because of the tannic acid in vinegars.

Thirty-one vinegar generators were built of white wood and Washington fir. Tanks from breweries were dismantled and the wood utilized for this purpose. The generators are four feet in diameter by nine feet high and two inches thick. They cost $43.00 each installed.

Five hundred feet of spruce logging four inches by four inches in ten foot lengths with one inch and one and one-half inch orifices, were bought from R. W. Bartelmann of Chicago, at twenty cents per running foot. This logging is installed permanently. Into it runs the vinegar and fermented juice from the supply tanks to feed the generators. Also the logging is used to conduct the finished vinegar from the generators to the finished product tank sunk into the ground below the generators. Couplings for the logging were bought from the Bushnell Pump Company, Bushnell, Illinois, at fifty cents each.

For each generator seventy bushels of beech wood shavings were purchased from the Redlich Manufacturing Company, Chicago, Illinois, at forty-five cents per bushel. Corn cobs and rattan, when available, may also be used and are cheaper.

Three sets of knives for grinding the apples and run by motor were purchased from the Hydraulic Press Company, Mount Gilliad, Ohio, at $18.00 per set. A grindstone for sharpening the knives was also purchased.

A small bottle filling machine, a bottle machine washer, a small

air pump used for mixing the vinegar cut with water to reduce to proper strengths desired, barrel conveyor to convey barrels of vinegar up from filling room to shipping platform, some piping and hose were bought from the Fleischmann Yeast Company at a very low figure.

A small amount of laboratory equipment was installed for chemical tests on vinegars and sweet cider stock. The apparatus consists of a small still to estimate the alcohol in fermented apple juices, also "sugar stems," glassware, burettes, etc.

The entire equipment with labor necessary to build benches, ladders, platforms, and arrange little odds and ends about the plant cost $11,000.00. Thus the total cost of putting property on Kingsbury Street in running order to manufacture one thousand gallons of cider vinegar per day was $26,000.00.

While the Chicago factory was being remodeled and equipped, a diligent search was being made for sites in Michigan. Two sites were finally bought, one at Fennville and another at Coloma. Both of these towns are in the center of splendid apple growing communities and have records of never having had a total failure of an apple crop.

Old buildings and ground were purchased. The locations are on the Pere Marquette Railroad. The repairing and equipping was done in a fashion similar to that in building the Chicago plant. Second hand tanks and machinery were bought and installed.

The Fennville plant located at Fennville, Michigan, on the Pere Marquette Railroad was provided with four hydraulic presses, and a storage capacity of two hundred thousand gallons of juice. Pumps, boiler, pulleys, etc., were in the building. Eleven thousand dollars was necessary to purchase the factory, site, and equipment and to put this station in a position to manufacture. Only apple cider is made here and the juice is shipped sweet to Chicago, or is stored and sent as needed partially fermented, either to Coloma or Chicago to be made into vinegar.

The Coloma factory is located at Coloma, Michigan, on the Pere Marquette Railroad. The equipment was installed. This consisted of tanks with four hundred thousand gallons storage capacity, pumps, mixing tanks, fermentors, boiler, pulleys, platforms, fifty-one generators, cooperage shop, and two

hydraulic presses. The total cost of equipment, ground, and building was fourteen thousand dollars.

To operate the Chicago plant, the cost is as follows:

Vinegar maker	$40.00	per week
Vinegar maker, helper	20.00	" "
One Cooper	30.00	" "
One shipping clerk	40.00	" "
Two helpers, each $24.00	48.00	" "
One office manager	50.00	" "
One stenographer	20.00	" "
One city salesman	50.00	" "

In busy seasons when large orders for bottled goods are to be filled, additional labor is hired.

The duties of the vinegar maker are to keep the generators running, to make the various "cuts" from higher strength to lower strength, and to test the alcoholic liquor, and the finished vinegar to see that full strength of vinegar obtainable is received from the alcoholic liquor.

The cooper's duty consists in repairing second hand barrels. All vinegar is sold in used wine or whiskey barrels. These from time to time need new heads, staves, iron hoops, or plugs to prevent leaking.

The shipping clerk handles the shop orders and fills, or superintends the filling of barrels and bottles of the various strength vinegars which run from 40 grain strength to 55 grain. (10 grains is equivalent to 1% acetic acid strength.)

The helpers are used about the plant to aid wherever needed.

The office man keeps books and attends to out-of-city trade. He is aided by the stenographer.

The city salesman attends to the city contract work and also aids in the office work by following up orders and keeping the trade supplied on general conditions of the vinegar market.

The Fennville plant is managed by a superintendent the year round at thirty dollars per week. His real work lasts about four months of the year—in the autumn. The remainder of the time is spent in making repairs and preparing for the next season's run of apples. He has one assistant at twenty dollars per week. During the rush time in the autumn he will hire from five to ten men and boys at fifteen dollars to twenty dollars per week.

The Coloma plant is managed by a superintendent at sixty dollars per week. He is a vinegar maker, attends to buying millions of pounds of apples, and in fact is responsible for everything about the plant. He has two steady assistants the year round besides a cooper and an engineer. In the busy season he will hire ten to fifteen men, boys, and women at ten dollars to twenty-five dollars per week. The pay of labor always depends, of course, upon its scarcity and the kind of work to be done.

The progress of the apple through the Chicago plant to vinegar is as follows: The apples are shoveled from the railroad cars down into the storage bin. From here the fruit is shoveled into the concrete washing bin where the apples are washed with running water. Any metallic substances settle to the bottom and careful watch is kept to prevent anything hard from going up the incline into the slicing knives. From the washing bin the apples go, via an incline belt composed of an iron chain and blocks of wood, to a set of motor driven knives. Here the apples are thinly rasped. The sliced apples fall into a hopper with a movable spout and are fed onto a press where a "cheese" is made up. When one press is squeezing out the juice, another press is fed to make up another cheese."

The sweet cider juice is squeezed out into a small tank, sunk into the ground below the press. From this receiving tank the juice is pumped into storage tanks or into fermentors. If the juice is sold as sweet, one-tenth of one per cent of sodium benzoate is added, and the juice barreled and sent out.

From the fermentors the alcoholic juice is pumped into storage tanks carefully painted on the outside with an asphalt paint and covered on the inside with paraffin to aid in preventing evaporation. The tanks are kept covered and in a cool place.

From the storage tanks the alcoholic juice is pumped into the receiving tank in the vinegar room. From here the generators are fed with the alcoholic liquor. From the generators the finished vinegar runs into a big tank sunk into the ground. From this receiving tank the vinegar is pumped into the big storage tanks from which it is drawn for barrel or bottle shipment.

Occasionally vinegar is filtered to give it brilliancy. This stock is used for fancy bottled goods. The filtering was formerly done through bone black, but now it is done through paper pulp

by pumping the vinegar up through the pulp as is done in breweries.

The cutting knives for rasping the apples are of steel and are sixteen inches long, about one inch wide, and three-sixteenths inch thick. They have teeth and look like a saw. Ten of these knives are set in slots in a drum. The teeth protrude above the periphery of the drum about one-sixteenth inch. The drum is motor driven and in revolving crowds the apple between the knives and the side of the box in which the drum is set. The effect is a rasping one. These knives may be purchased from the Hydraulic Press Company, Mt. Gilliad, Ohio.

The presses used for squeezing out the juice from apples are of two types, the screw type and the hydraulic. The former may be purchased from Boomer & Borchert, Syracuse, New York; the latter from the Hydraulic Press Company, Mt. Gilliad, Ohio. The screw types in the Chicago plant are motor driven. The hydraulic presses in Michigan are run by steam. They may also be run by motor. The screw type operates similar to the ordinary hand screw press. A platform operating on long screws is let down on a "cheese," which is made up on a small car run on tracks. The box of the car is fifty-four inches square and four inches high. When the "cheese" is made up on the car, it is pushed underneath the press and the platform let down on the car. An indicator is so calibrated that when enough pressure has been applied to procure all juice available, it swings down and registers this fact. This operation takes, roughly, about one hour. With this type of press a six hundred pound cheese, and about forty-two to fifty gallons of juice may be pressed per hour. In a ten hour day four hundred to five hundred gallons of juice per press may be squeezed out.

The hydraulic press operates with a piston-like motion. A broad base is pushed up. The "cheese" is lifted against the top and a pressure of four thousand pounds per square inch is applied. The hydraulic press will produce from fifteen hundred to two thousand galllons per ten hour day. It is easier to operate and takes up much less room. This type of press costs about twice as much as the screw type, but is far more economical to use. This type of press may be purchased from the Hydraulic Press Company, Mount Gilliad, Ohio.

The "cheese" is made up by leading the rasped apples from the hopper immediately under the knives by aid of a chute to the car. A large sheet of canvas is laid over the box of the car. The rasped apples are let in, and a layer of about four inches is made. Then the ends of the canvas are folded over the top of the rasped apples. On the top of the folded ends of canvass a thin lattice work of wood is laid. Then another large sheet of canvas is laid over the lattice work of wood. Another four inches of apples is run on, and the canvas ends are folded over, and another frame is put on top. The "cheese" is then built up until it is about four feet high. Then the car is run under the press. While the press is operating on one "cheese," another "cheese" is built up.

The "first-pressings" is the name given to the cider juice expressed from the "cheese" after about an hour's pressure. This amounts to about seven gallons per one hundred pounds of apples. This juice is the richest in all the ingredients that make up sweet cider. The richness of the juice of course depends on many things: i. e., the quality of the fruit from the standpoint of decay, ripeness, and variety.

The "second-pressings" is the name given the juice expressed from the pomace after the "first-pressing." The method of procedure producing the best results is to take the pomace after "first-pressings" and allow it to partially ferment in warm water at about 85° F. for four or five days. But this is against the food regulations of most states. This is, however, the procedure in Germany. In Michigan the law states pomace for "second-pressing" must be repressed within twenty-one days; also water must not be added and the pomace must be kept under cover.

The pomace is built up in "cheeses" and squeezed in a similar fashion to the "first-pressings." From one to three gallons of juice per one hundred pounds of apples are received. The "second-pressings" of course are not as rich as the "first-pressings." The pomace is the apple residue left after expressing "first or second pressings." When only "first-pressings' are expressed from the apples, the pomace may be sold for jelly filler. When the "second-pressings" are expressed from pomace, the dried pomace is used for fuel in the boiler.

Pomace should be repressed for "second-pressings" within

four days after "first-pressing." Much depends on weather conditions. The colder the weather the longer the pomace may lie. If the weather is warm the pomace will sour and prevent the subsequent juice from properly fermenting to alcoholic stock for vinegar.

Sweet juice is bought from the farmers, from apple canners, (this stock is usually made from skin and cores), and repress stock from sweet cider manufacturers. This outside juice should always be analyzed for the following: Acidity, alcohol, sugar, solids, soluble and insoluble P_2O_5, alkalinity of ash, optical rotation, sugar and non-sugar solids. A price is then offered. This kind of business usually does not pay unless the quantity amounts to a tank car or more. A tank car holds from seven thousand to ten thousand gallons of juice.

The juice is pumped into fermentors that hold from six thousand to ten thousand gallons. The yeasts always present in the juice are usually allowed to do the fermenting. Sometimes a brewery yeast bought from breweries or a selected pure culture yeast is added to the sweet stock. The sugars are then converted into alcohol and carbon dioxide according to the formula $C_6H_{12}O_6$+yeast gives $2C_2H_5OH+2CO_2$.

One hundred parts of sugar give 51.11 parts of alcohol and 48.89 parts of carbonic acid. This is the theoretical yield, but actually only about 92% of the theoretical yield of alcohol is obtained.

The sucrose present in the juice is not directly fermentable. By means of an enzime that exists in some yeasts the sucrose is inverted to dextrose and levulose. These sugars are then converted into alcohol and carbon dioxide.

From time to time some of the juice is tested with a brix hydrometer to observe the progress of fermentation. When the juice is fermented to O on the sugar-stem, all the sugars are fermented.

The fermented juice is a variable product. Depending on the temperature, the race of yeast predominating in the fermentation, the variety, soundness, and the ripeness of the apples used for sweet juice, varying amounts of the following are obtained: alcohol, glycerine, succinic acid, lactic acid and butyric acid; de-

ANALYSIS OF "FIRST PRESSINGS."

Variety	Season	Solids	Invert Sugar	Sucrose	Total Sugar	Ash	Rotation 400 mm. Ventzke Degrees left.
Ben Davis	Winter	12.96%	7.22%	4.01%	11.23%	0.29%	49.00
Baldwin	Winter	17.01%	8.16%	7.28%	15.44%	0.27%	39.00
Red Astrachan	Winter	12.94%	7.03%	3.72%	10.75%	0.39%	23.72

ANALYSIS OF "FIRST PRESSINGS" OF MIXED APPLES AND OF THE POMACE.

Apples	79.15%	20.75%	10.56%	3.14%	0.35%
Pomace	31.73%	31.73%	3.52%	1.05%	0.52%

ANALYSIS OF "FIRST AND SECOND PRESSINGS" FROM SOME APPLES.

	Sp. G.	Solids	Invert Sugar	Sucrose	Total Sugar	Total Sugar after Inversion	Ash	Rotation 400 mm. Ventzke Degrees left.
"First Pressings"	1.601	3.14	11.3	2.45	13.75	13.97	0.30	45.67
"Second Pressings"	1.062	2.61	7.24	1.38	8.62	8.76	0.39	30.14

pending on the variety of apple, section of the country where apple is grown, and degree of ripeness, varying amounts of soluble and insoluble P_2O_5, K_2O, Na_2O, and CaO are obtained in the juice with varying amounts of sugar and non-sugar solids.

The temperature best for the fermentation varies with the race of yeast predominant in the fermentation. The products of fermentation vary with temperature and type of yeast predominant in the fermentation. In practice too little attention is paid to the fermentation, because under the great stress of rush work with limited space to handle millions of pounds of apples, the only thought is to finish the stock and send it moving to completion as rapidly as possible.

Temperature control with a pure yeast is the best way to handle the cider stock. With wild yeasts and moulds fermenting the sweet stock, considerable sugars are destroyed with loss of alcoholic yield. Some moulds destroy as high as 12% of the sugar in fermenting.

The most suitable temperature for fermentation is 18° to 24° C. (65° to 75° F.).

To ferment to O the sugars in six thousand to ten thousand gallons of juice takes about a week's time.

TABLE SHOWING DIFFERENCE BETWEEN JUICES FROM RIPE AND GREEN APPLES.

Variety	Ripeness	Invert Sugar	Sucrose	Total Sugar	Ash
Ben Davis	......Ripe	7.11%	4.15%	11.26%	0.28%
Ben Davis	.....Green	6.56%	0.68%	7.24%	0.32%

ANALYSIS OF SOME FERMENTED JUICES OF MIXED APPLES JUST BEFORE GENERATING TO VINEGAR.

Solids	Acidity	Alcohol	Ash	Rotation 400 mm. Tube Ventzke Scale Degrees left.
1.96%	0.46%	7.23%	0.22%	2.46
2.91%	0.62%	6.64%	0.28%	2.24
1.91%	0.58%	4.65%	0.24%	4.10
3.32%	1.20%	9.81%	0.34%	1.94

After fermentation the generator converts the alcoholic liquid into vinegar. It is an arrangement to allow air to pass up through material held in a container through which the alcoholic liquor passes down in fine drops.

The generator usually is nine feet high and four feet wide with staves about two and one-half inches thick. It is made of white wood or of oak. Six inches from the bottom on the inside a perforated false bottom is placed. Inch holes are drilled through this about three and one-half inches apart. Twelve inches above the false bottom of the generator, four holes are drilled in from the outside slanting down to the inside. These holes are about three-quarters of an inch in diameter. They are the vents which regulate the air supply going up the cask by aid of plugs. They are placed equally apart around the tank. The oxygen of the air oxidizes the alcohol of the juice to acetic acid.

About a foot down from the top of the cask is fitted what is called a "dumper." This dumping arrangement consists of a long axis with a scoop on each side. The alcoholic liquor coming through the vent in the top of the cask feeds into one of the scoops on one side of the axis. When heavy enough with liquid the scoop tips and pours out its contents over a perforated disk. The holes in this disk of wood are about one-eighth inch in diameter and placed from two to three inches apart. This disk is for the purpose of spreading the liquid. When one side of the axis dumps its liquid, the axis rotates and brings into position the other scoop which is then filled and operates in a similar fashion as described.

Between the false bottom and the perforated disk on top, immediately under the dumper, are placed beechwood shavings, corn cobs, or rattan. These give the surface to the liquid and spread it out into thin drops The rattan is stamped down in the generator while the corn cobs and beechwood shavings are placed in loosely.

In cider vinegar making, the greatest care must be exercised in the management of the generators. Much money may be lost by not receiving the full strength vinegar from the alcohol in the juice. Alcohol is lost in evaporation and destroyed by vinegar fungus. The generator should be carefully cleaned out about every three weeks and new filling put in. Every two or three days the top perforated disk should be cleaned of "mother"

(fungus growth) and if necessary the top layer of cobs or beechwood shavings removed when covered with "mother." The "mother" forms a thick film and air cannot pass through the generator.

The generators are placed in rows and sufficient space should be between each one to enable a person to walk around it. They are connected on top and bottom with wooden logging. The top logging runs over the entire row. Over each generator a faucet connected to the logging feeds the "dumper" through a small hole. If generators are incapacitated, the faucets over them may be turned off without interfering with the others that are in good working order. From the bottom of each generator a faucet leads to a pipe of wood or logging, and this logging conveys the partially finished or finished product into a receiving tank sunk in the ground. The generator room should have all the fresh air possible and no direct sunlight.

I will assume the most difficult case in the making of cider vinegar, i. e., starting with fresh generators, with fresh shavings or corn cobs. The filling in the generators is flooded with strong cider vinegar and soaked. From forty to sixty grain vinegar is used for this. The vinegar retains a great many vinegar bacteria and these lodge in the shavings or filling. These bacteria of a number of different species propagate and act when the temperature is correct, as a catalytic agent in the conversion of alcohol to acetic acid by oxidation with air.

After soaking for several hours the vinegar is run out in a steady stream, and as fast as it runs out, it is fed in at the top from the filling tank. This is continued for about a week or until the time when the generators become warm. The generators are now ready for alcoholic liquor. The strength of vinegar that may be made is restricted, due to the effect of strong alcohol and strong vinegar on the bacteria. A ten per cent alcoholic liquor will kill them. But long before that strength is secured their activity is checked.

If forty grain vinegar has been used to "heat up" the generators, then this vinegar is diluted in the "mixing tank" with the alcoholic liquor until the mixture shows a twenty-two grain strength of acetic acid. Then this mixture is fed by gravity to the generators in small steady streams through the faucets above

ANALYSIS OF APPLES FROM THE MICHIGAN PLANT

Variety	Season	Water	Solids	Invert Sugar	Sugar	Total Sugar	Total Sugar after Inversion	Free Malic Acid	Ash
Sweet Rough	Summer	84.2	15.80	7.83	3.01	10.84	11.01	0.12	0.29
Red Astrachan	Summer	83.9	15.61	6.81	3.60	10.41	10.86	1.02	0.39
Early Strawberry	Summer	84.31	15.69	5.46	4.22	9.88	10.06	0.91	0.31
Greening	Winter	83.15	16.75	7.21	5.35	12.56	12.78	0.74	0.28
Golden Russet	Winter	76.01	23.99	11.95	5.12	17.07	17.41	0.80	0.35
Baldwin	Winter	79.81	20.19	7.91	7.0	14.91	15.24	0.72	0.29
King	Winter	83.70	16.30	8.01	4.08	12.09	12.42	0.56	0.28
Ben Davis	Winter	84.95	15.05	7.02	3.62	10.64	10.82	0.67	0.27
Northern Spy	Winter	82.37	17.63	9.64	3.46	13.10	13.45	0.70	0.31
Jonathan	Winter	85.01	14.99	7.51	3.82	11.33	11.56	0.60	0.23

each generator. The finished product from the bottom of each generator flows into the receiving tank. From here it is again pumped into a mixing tank and the "mix" diluted to twenty-two grain acetic strength with alcoholic liquor. This is continued until the generators are about 90° to 93° F. in temperature. They are then ready for their maximum production. Twenty-two grain vinegar with 2% alcoholic strength should now give, on going through the generators once, forty-two grains acetic strength of vinegar. They are now ready to make any strength cider vinegar that may be made from the alcoholic cider stock.

If forty grain vinegar stock is to be made, then the "mix" in the mixing tank is held at twenty-two grains. If fifty grain stock is to be made, then the "mix" is held at thirty-two grains. This is done in this manner, because the alcoholic liquor in its progress through a generator will increase in acidity, when conditions are proper, from fifteen to eighteen grains. This is a safe working condition. If more acidity is produced, the generator is very likely to "go bad," and then the entire "filling" will have to be replenished.

When fermented cider stock tests fifteen proof alcohol, it should produce sixty grain vinegar. But evaporation, generator trouble (feeding generators too fast or too slow), and the almost unavoidable growth of mal-organism may cut this as low as thirty grain. Therefore, it is necessary to have a skilled cider vinegar maker in constant attendance.

A temperature from 90° to 95° F. appears to be the most suitable for best working conditions. This may be observed either by inserting a thermometer in the generator or taking the temperature of the vinegar coming out. If the temperature runs 15° to 20° F. over 95° F., the generator may "burn out," i. e., the bacteria may be destroyed. Then the generator must be refilled and gradually brought up to working conditions, i. e., "heated up." The temperature is regulated by plugging the air vents or by feeding the alcoholic liquid fast or slow. The faster the "feed" the higher the temperature rises, and the more air is required. The flow of the "feed" to each generator is controlled as follows: The "mix" is led from the mixing tank by wood logging running over all the generators. Over each generator a wood faucet fastened in the logging controls the flow. This flow is so regulated that each

generator produces about one and one-half gallons of cider vinegar of forty-five grain strength per hour. The height of the vinegar in the receiving tank is measured from time to time with a yard stick. This gives the number of gallons in the tank. The increase may thus be noted from time to time. The number of working generators being known, the control flow faucets over each generator are fixed to maintain the one and one-half gallons per generator per hour. If the cider vinegar is to be stored, a small amount of alcohol should be left in it. This appears to keep it. If it is all converted, mal-organisms and oxidation may decompose the acetic acid to carbon dioxide and water.

SOME ANALYSIS OF PURE CIDER VINEGAR.

Solids	Acetic acid	Alkalinity of ash	P_2O_5 Per 100 cc.	Insol. P_2O_5	Rotation 400 mm. Tube Ventzke Scale to left.
1.98	4.56	29	11	6	0.4
2.35	5.15	31	12	8	1.5
3.10	6.10	33	16	15	2.9

The apples usually bought for cider purposes are the poor colored, the knarled, the specked, the undersized, the windfalls, and others unfit for table use and canneries. They are bought by the hundred pounds from the farmers. Sometimes the Chicago plant procures from South Water Street commission men over-ripe apples or frost bitten ones.

A NEW USE FOR RE-ENFORCED CONCRETE.

Another use for re-enforced concrete is in connection with the foundation for electrical generators. Hitherto metal castings, weighing several tons, have been used for the purpose. In addition to the great saving in cost which would result from the substitution of concrete for steel, the delays experienced in procuring such parts from the manufacturers would be saved, as the foundations could be manufactured on the site.

APPLICATION OF PROTECTIVE RELAYS TO CENTRAL STATION PRACTICE.

By Cliton E. Stryker, '17.

The principal objects to be attained by the use of protective relays are: the insurance of continuous service, and the protection of apparatus. These ends are obtained by the use of a great variety of apparatus and many different systems of connections. This particular article treats of the application of these services to but one central station company and should not be assumed to cover the entire field. However, as this central station is one of the largest in existence and covers a wide variety of service, its methods may be assumed to be illustrative of general practice.

Relays and other protective devices are used on the following classes of apparatus:

Generators (steam driven),
High tension lines or feeders,
Railway synchronous converters,
Railway D. C. feeders (600 volt),
Edison synchronous converters,
Edison D. C. feeders (3 wire—115 and 230 volt),
Motor generator sets (frequency changers),
Station transformers,
Industrial transformer banks,
A. C. high tension distribution circuits,
Special applications.

Generators (steam driven).

Practically all central station generators are alternators, so that this type only is considered. The protection needed on generators is as follows·

Overload,
Internal short circuit,
Over-speed.

The most approved practice at present does not include protection against overload, as it is assumed that the operator pays sufficient attention to his machines to prevent any considerable overloading. The fluctuations in load on a large system are rela-

tively slow and can be taken care of by manual operation. Short-circuits on lines are taken care of by line relays and the only contingency which would affect the alternators would be a short circuit on the station bus, which is a very rare occurrence. Another point of importance is the fact that modern high reactance alternators are largely self-protective in that their short circuit current is not great enough to destroy the windings. The objection to the use of overload relays is the fact that they are likely to operate in the event of a line failure near the station, before the line is cleared by its relays. This would cause a complete interruption to service instead of the interruption of only the line affected.

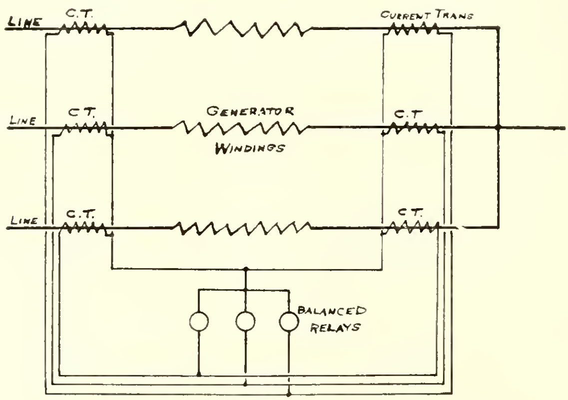


Fig. 1. Generator Protective Relays.

The alternators are protected against internal short circuit by instantaneous balanced relays which are connected as in Fig. 1. These relays function in the event of an unbalance in the current in any given phase and trip all generator switches, the field switch, and the steam valve. In machines equipped with motor driven blowers, these are also stopped. In other words the machine is completely shut down. As can be seen, the only action which would cause an unbalance in the currents would be a short circuit or ground on a winding, which would cause the current to flow into that winding through both the phase lead and the neutral lead.

The over-speed trip operates when the speed reaches a value of about 115% of normal speed and only trips the emergency steam valve. It is not necessary to shut down the electrical end of the machine, as there is practically no chance of the system frequency rising enough to cause any damage.

High tension lines or feeders.

The protection of direct stub-end lines or feeders is a very simple matter, involving only the use of time limit overload relays. Unfortunately, however, the stub-end line is a rarity in the modern central station system. Practically the entire high-tension system is made up of a series of loops forming a network, which makes the protection of these lines a complicated and difficult matter. Considerations of economy of copper and facility of operation dictate that a network be used, so that it is imperative that relay systems be devised which will protect such a network.

It might be stated that the problem of network protection is far from being solved at the present time, but that improvements are being made rapidly and it is hoped that network protection will soon cease to be the chief worry of the central station relay engineer.

The usual procedure in applying relays to a network is to divide it into a number of loops and work out the protection of each loop. A typical loop is shown in Fig. 2. The principal types of relays used in this work are:

Time limit overload,
Unidirectional overload (Reverse power),
Instantaneous differential balanced.

The time limit overload relay (Westinghouse Type C O) functions when the current exceeds the setting value for a predetermined length of time. It has inverse time characteristics in that the greater the current the quicker the relay will close. This relay closes irrespective of the direction of current flow. The unidirectional overload relay (Westinghouse Type C R) has all the above characteristics except that it operates only when the current flows in a certain direction and will not operate when the current flows in the opposite direction, regardless of the value of the current.

The differential balanced relay is a specially devised apparatus

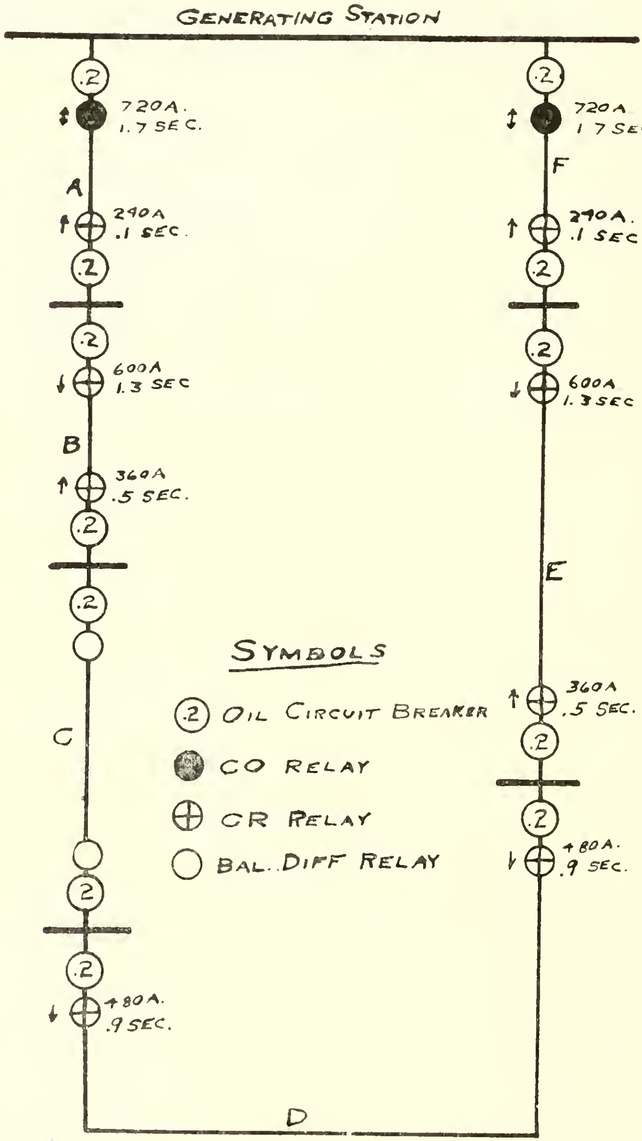


Fig. 2. Typical Line Loop.

for the protection of service by cutting out defective lines instantaneously. It functions only in the event that current feeds into both ends of a line, which will only occur if a short or ground develops. It does not protect the line itself in any way so that it is usually used in conjunction with other types of relays.

The connections of a set of differential balanced relays are shown by Fig. 3. The relay proper consists of two windings

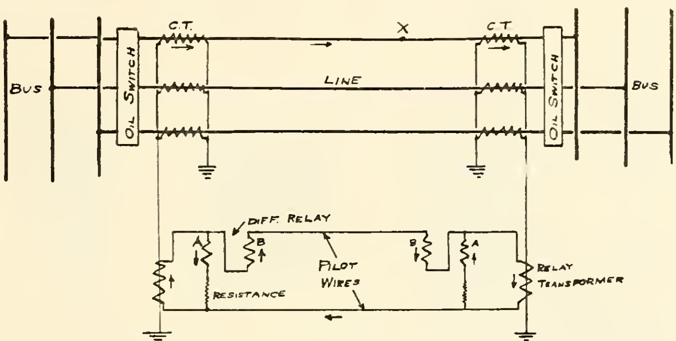


Fig. 3. Balanced Differential Relay.

(A & B) so connected that under any normal condition the fluxes produced by the two windings are in opposition and are neutralized, thus preventing the relay from closing. By reference to the diagram it will be seen that, with a balanced load, no current will flow in the relay circuit inasmuch as the resultant of the currents from the line transformers is zero. In the event of an unbalanced load, say a load on one phase only, currents will flow in the relay circuit as shown by the arrows and the flux in the relays will be zero. In this connection, an unbalanced load is considered as one in which there is a current in the neutral conductor. In a system operating without a neutral conductor, such a lack of balance could be caused only by a fault on one phase of a line, which would permit a flow of current thru the ground to the neutral of the generator grounded in the station. As an example, a fault on a line beyond the one equipped with the differential balanced relays would cause such a current, but this would not operate the relays on the line considered. If we

now assume a fault at x it is apparent that the current will flow into the cable from both ends. This will cause a reversal of the current in the coil A of one of the relays and will also cause the current in the B coils to decrease in value. On account of this fact the flux produced by the A windings will not be neutralized and the relay will close. Ordinarily one relay will function before the other, but this will still further unbalance the current and will hasten the operation of the other relay.

The loop shown in Fig. 2 is protected in the following manner: The entire loop is protected from overload by the overload relays at the generating station. These relays have a high time setting so that a fault in the loop will be cleared by the other relays before they will operate. However, a long continued overload will close them. A fault on line A will be cleared by the operation of the C R relay on the sub-station end of this line, and the C O relay at the generating station. It should be noticed that the C R relay on this line has a lower time setting than any of the others operating on current flow in the same direction. This insures that the correct relay will operate and that one nearer the other end of the loop will not operate first and disconnect lines which are not faulty.

Lines B, D, and E are equipped with C R relays at both ends with their time settings so chosen that they will not operate in the event of a fault on any line beyond the one on which they are installed. Line C is equipped with differential balanced relays and cuts out instantaneously in the event of a fault on the line itself. One line near the center of the loop is usually equipped with this type of relay. Line F is equipped in the same manner as line A.

The above concrete example gives a general idea as to the manner of protecting line loops. From the discussion it might appear that it would be best if all lines were equipped with differential balanced relays. Perhaps this is true, but due consideration should be given to the fact that these relays require that two pilot wires be run the entire length of the line, which makes their installation expensive and therefore undesirable on the score of economy.

In general, the overload relays on lines at the generating stations are set at about 350% of full load line current. The time

settings of the relays take into account the fact that oil circuit breakers require a perceptible length of time to open, the average value of this time for a modern oil circuit breaker (G. E. K 12) being 0.2 second. Lines or feeders which run from station to station are practically always controlled by three-phase circuit breakers, so that the operation of a relay opens all phases of the line.

It can safely be said that more trouble has been had with line protective relays than with any other form of protective apparatus. Many difficulties have developed after the installation

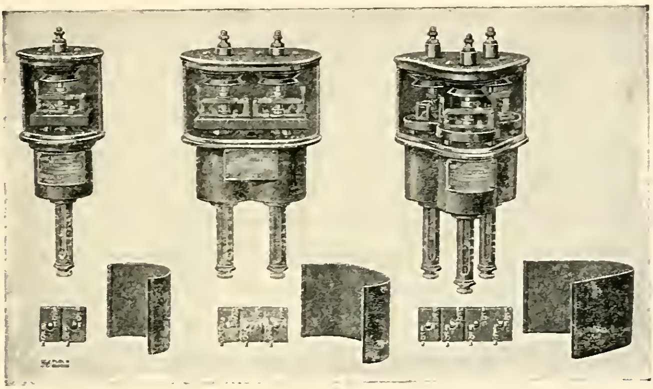


Fig. 4. Inverse Time Limit Overload Relay. (G. E. Co. Type H, Form G.)

of apparatus and have been removed only with great expense. As an example, several earlier designs of balanced relays proved to be absolute failures on account of inductive and capacity effects of the line currents on the pilot wires. Even the apparatus here described is not perfect. The differential balanced relay will not function in the event of a fault on a line which is perfectly balanced on all phases. A relay system has been devised which will function correctly on any and all faults but it requires three pilot wires and six relays on each line and is therefore too expensive to be considered except for special cases. Operating experience has shown that with high time settings on the C O relays at the generating stations, a fault on the line directly out of the station may cause a disastrous system disturbance before

the relay operates. To obviate this condition, instantaneous relays with extremely high current settings have been installed in some cases in addition to the other equipment, which will operate in the event of a fault on the line directly out of the station. These relays are set so high that the impedance to a fault on any line beyond the first substation will limit the current to such a value that the relay will not close.

Railway Synchronous Converters.

Synchronous converters in railway service are subject to sudden and wide variations in load and must be protected accordingly. The standard railway D. C. voltage is 600, which means that arcing and flashing troubles are likely to be serious. Converters are equipped with circuit breakers on both the A. C. and D. C. ends, and relays can be applied accordingly.

Ordinary overloads on railway converters are taken care of by the overload trip on the D. C. circuit breaker, which is set for 125% load. This takes care of sudden swings and allows the machine to continue running from the A. C. supply. Service can therefore be restored very quickly, which would not be the case if the A. C. circuit breaker opened and shut down the machine. Machine failure is taken care of by the overload relays in the A. C. circuit which are set to operate instantaneously on 350% load. Standard bellows type (G. E. Type P) relays are used for this work.

As railway machines are subject to flashovers, special relays are provided to take care of this contingency. The converter frames are insulated from ground except that they are connected to ground through the flashover relay coil. Therefore, all ground current passes through this relay. Most flashovers develop between the commutator and machine frame, which causes current to flow through this relay. The relay will then close and will open both the A. C. and D. C. circuit breakers, thus cutting the machine off completely.

The other protective device used on railway converters is the overspeed trip. As is well known, an inverted synchronous converter feeding a highly reactive load will operate with a greatly weakened field and may easily reach dangerous speeds. If a fault occurs on a transmission line feeding a converter which is connected to a D. C. system also supplied by other converters this

exact situation is likely to occur, with disastrous results. Converters are therefore equipped with overspeed devices which open the D. C. circuit breakers in the event of the machine reaching 115% of synchronous speed. Railway converters are also equipped with low voltage releases on the D. C. circuit breaker, which will open this breaker in the event that the D. C. bus voltage drops to a low value.

Railways D. C. Feeders (600 volts).

The railway D. C. feeders are protected by overload circuit breakers which will open in the event of an overload or short circuit on the trolley section supplied by the feeder. In the system under discussion the railway D. C. distribution system is cut into short sections, which are not interconnected, so that the difficulties incident to a network are not encountered.

Edison Synchronous Converters.

The Edison three-wire 115-230 volt D. C. system is also supplied by synchronous converters but as this service is essentially a constant load proposition, the method of protection is different than that applied to railway converters. In addition to this, most Edison systems are very intricate networks, which change the situation as to the protection required. It has been found that it is very undesirable to have instantaneous overload relays on machines in this service, as the possibility of service interruption is too great. For this reason, the only overload protection on Edison system converters is furnished by time limit relays on the A. C. side of the machine. These relays are set to operate on 330% of full load current in 2 seconds. They will operate instantaneously on a current in excess of 440% full load value.

Inasmuch as these machines are operated in parallel on a network which also carries floating storage batteries, it is necessary to provide reverse current protection. The reverse current relays operate in the event of D. C. feeding back into the converter and open the D. C. circuit breakers. Overspeed protection is the same as on railway machines. It is essential that both D. C. circuit breakers open simultaneously as these are three-wire machines, and if only one breaker opened, current would still flow through the other side of the machine and the neutral. This condition would perhaps be worse than if both circuit breakers remained closed.

Edison D. C. Feeders (3 wire—115 and 230 volt).

The feeders on the Edison system are tied into a network which is extremely complicated. It was found, early in the operation of such a system, that almost any method of protection would be a failure. For this reason, the present practice is to tie these feeders direct to the busses, no fuses or circuit break-

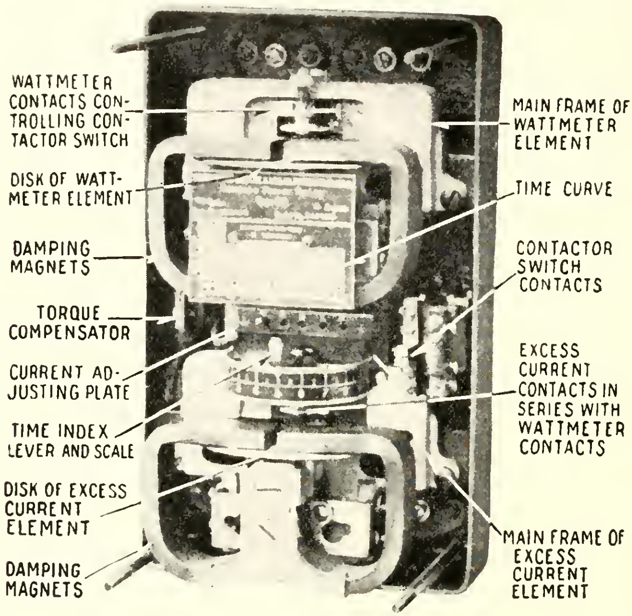


Fig. 5.

ers being used. In case a cable grounds, the only manner in which it could be cleared would be for it to burn off, which usually happens without any serious disturbance to the system. It should also be noted that failures on these cables are extremely rare.

Motor Generator Sets (Frequency Changes).

Motor generator sets or frequency changers are used to convert 25 cycle energy to 60 cycle or vise versa. They are used mostly as emergency machines in the case of a shortage of power on either system. The two units in these machines are protected

separately by overload relays. As these machines are used principally to change from 25 cycle to 60 cycle, the 60 cycle generator relays are set for lower current values than the 25 cycle motor relays. Typical setting values are 200% load on the generator and 220% load on the motor, both values being based on two second operation.

Station Transformers.

Three phase transformers are used to transform 60 cycle power from the transmission voltage (12000) to the high tension distribution circuit voltage (4000). These transformers were originally protected by overload relays on the primary and secondary arranged to operate the same as those on motor generator sets. It was later found to be desirable to eliminate these overload relays and use instead differential relays which would operate only in case current fed into the transformer in both primary and secondary. These relays of course do not protect the transformers but only insure continuity of service by clearing defective apparatus from the system.

A serious difficulty was discovered in the application of this type of relay because of the fact that a failure on a secondary bus would not be cleared until all lines feeding the station opened. This was overcome by the addition of time limit overload relays on the primary of the transformers with very high settings. These were intended to operate only when the current rose to short-circuit value.

Industrial Transformer Banks.

The present tendency in supplying large customers is to furnish them energy from transformer banks connected directly to the transmission system. These banks present a somewhat special problem as they are usually operated without an attendant. It is therefore desirable to limit the operation of protective devices to extreme emergencies. These banks always supply 110, 220, or 440 volt power direct to the customer's switchboard, which is equipped with the usual circuit breakers. These circuit breakers are accessible to the customer's employees and are therefore set to open in the event of overloads, etc., on the customer's promises. The oil circuit breakers on the primary of the transformers are ordinarily in a locked room and therefore their opening may mean that service will be interrupted for a considerable length of

time. Accordingly, the primary relays are set to operate on 600% full load current, which could only flow in the event of a transformer failure or failure of the secondary circuit breakers.

A. C. High Tension Distribution Circuits.

These circuits are all stub-ended and feed from the station 4000 volt bus. The requirements in this case are completely covered by the use of time limit overload relays set to open instantaneously on 300% of full load current. The distribution transformers connected to these circuits are protected by standard pole-type cutouts.

Special Applications.

There are many special applications of protective devices in the modern central station system. Among these may be mentioned: no voltage alarm relays to notify the operator in case a bus goes dead, reverse phase relays to protect motors, no current relays for the same purpose, and watt relays to open feeders when a certain amount of power has passed.

The foregoing discussion should indicate that the modern tendency is to protect the service rather than the apparatus. As reliability is one of the principal advantages of central station service it is of paramount importance that continuity of service be maintained, even at the cost of damaging apparatus.

The problems of protection have grown in proportion to the size of the central station systems and are today of great magnitude. When it is remembered that there are systems in operation with a connected load of 500.000 kilowatts and that the short-circuit energy of such a system may be many times this value, it will be realized what measure of protection is needed if apparatus is not to be destroyed and service rendered unreliable.

SALESMANSHIP.

By Harry Clay Coffeen.

Life Insurance Specialist, with Chicago Agency of Northwestern Mutual Life Ins. Co.

Salesmanship is the process by which a sale is consummated. A sale is made any time a person, who owns or controls a thing or an idea, brings another to think nearly enough the same about it, to become its possessor and to pay the price asked as equivalent.

We are given to thinking of only a small group of engineers as salesmen, when the facts are, that every succesful one among them is a salesman. Not only are they salesmen of machines, but of ideas, and no original suggestion or new plan is put into operation, except through selling it to those who need it.

Certainly no one ever went to work for another in the most indifferent capacity, without selling his services to his future employer. Thus no matter what wonders you are able to produce in ideas or goods, if you cannot sell them broadly to those to whom they will prove helpful, the world will miss what should rightly be your contribution to its progress.

There are volumes written on this subject of salesmanship, particularly of late, on the application of the principles of psychology to its effective practice. The purpose of this article is to interest you sufficiently to start you reading on the subject. Having started, the wealth of interest and information will keep you studying toward the desired results.

The background of salesmanship of goods is confidence, training, and experience.

There must be confidence in the goods, based on detailed information of them, confidence in the organization producing the goods, and confidence in yourself, as to your ability and preparation to present to a buyer a comprehensive view of these goods and what they will do; all this produces confidence in the buyer himself, which is fundamental to a satisfied and lasting relationship of client to salesman.

There must be training in the detailed knowledge of goods and of their manufacture, in the understanding of the field in which they are to be sold, and in the comprehension of the principles of applied psychology, which will bring the minds of the buyer and salesman together. This leads among other things, to economical use of time and thought in attaining results.

There must be experience in actual selling. One must know as

the result of his own work that certain suggestions will lead to attention, so he may be heard; that others will lead to interest-provoking questions which will lead to understanding, and that answering objections effectively will create desire. Finally he must know of his own motion how desire must be molded into action.

Salesmanship is founded on scientific principles, but is an art, in that it must be "practiced to make perfect."

The goal of salesmanship is service. Temporary success may be based on a fad, or on a weakness, but permanent rewards come from meeting a real need.

The above suggested principles are particularly applicable to my own business, that of "selling" policies of life insurance to individual buyers.

One must have confidence in the institution itself, must believe in the almost universal need for its service and that it fills that need, even to being the greatest economic stabilizer the business world has ever known. He must believe in the soundness of his company back of the policy and that the experts in each department practice scientifically sound principles, from selection of risks and collection of the funds, through safe and profitable investment, to honest distribution to beneficiaries served.

In order to have and hold the desirable degree of confidence in one's own ability to broadly serve his clientele, he must be a thorough student of this subject. He must not only understand in detail the foundation, the meaning and the effect of each clause in policy contracts of all kinds, but he must appreciate people's needs based on changing business economics, in which latter he must keep up to date.

Finally after full preparation and thoroughly selling one's self, the greatest necessity is actual practice in getting one's ideas into the minds of others. To an attentive and earnest student of one's own progress, his continually changing methods are a source of constant and pleasurable interest.

One of the most helpful first books on this general subject is "The Selling Process," by Norval A. Hawkins of Detroit. If you are the least interested you ought to see it in the library and if you intend to engage in actual selling you ought to own a copy of the book. Reading some such text will broaden your views and it may lead you to conclude that selling will prove a profitable and satisfying occupation for you.

SPECIAL TESTING EQUIPMENT—MECHANICAL ENGINEERING DEPARTMENT.

By G. F. Gebhardt.

Scientific Research in the Mechanical Engineering Department of the Armour Institute of Technology has been conducted chiefly in connection with Senior theses for the degree of Bachelor of Science in Mechanical Engineering. Notwithstanding the limited time available for this class of work and the inexperience of the student investigators, very creditable results have been obtained. No attempt will be made to enumerate the various problems investigated in this connection, but a brief description of some of the more important and novel testing equipment, most of it constructed by the students, may be of interest.

Automobile-Tire Shock-Absorption Machine: Two general types of machines have been developed for comparing the shock-absorption properties of automobile tires—the "service" and the "laboratory." The former consists essentially of a modified seismograph mounted on the automobile chassis for recording the vibrations under road conditions, and the latter a specially designed "bumping" machine for recording the displacement of the axle when the tire rides over an artificial obstruction.

The tire to be tested is mounted on a suitable automobile wheel and axle and when rotated by means of a motor drives a pulley attached to an absorption dynamomoter. A small block attached to the periphery of the pulley constitutes the obstruction. The wheel is loaded by means of dead weights attached to a spring-mounted beam near the bottom of the machine. The end of the spring is flexibly connected to a ball bearing housing encircling the driving shaft. The housing is constrained by ball bearing guides to move in a vertical direction only, and its displacement is recorded on a revolving chart through the agency of a pantagraph. With this device it is possible to test tires for shock-absorption under exactly parallel conditions, as regards dead load, speed, power and height of obstruction.

Horsepower Meter: One of the most ingenious and useful of the various testing outfits in the gas engine laboratory is the horsepower meter shown diagrammatically in Fig. 1. This apparatus enables the driver of a chassis to determine the traction

effort and the horsepower delivered to the rear wheels at any instant without the need of calculation. The chassis is backed up on the test platform so that the rear wheels engage with corresponding pulleys of an absorption dynamometer and the frame of the vehicle is attached to an indicating traction dynamometer. The driver then needs only to drive the machine at various speeds, and the traction effort and horsepower developed at the rear wheels are automatically indicated by the mechanism of the meter.

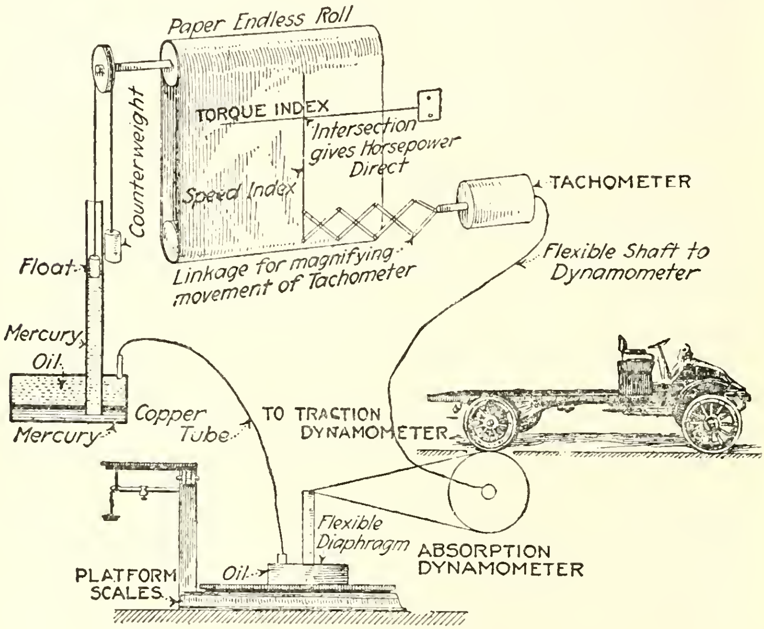


Fig. 1.

Referring to Fig. 1, rotation of the rear tires is transmitted to the two large-diameter wheels of the dynamometer. The brake load on the dynamometer arm is transmitted through a copper tube, from an oil filled chamber on a platform scale, to an oil reservoir as indicated. The oil pressure, through the agency of a mercury column, actuates a balanced float, the movement of which is transmitted to an endless roll of paper. The displacement of the paper roll is a direct measure of the torque since the brake arm is of constant length. The brake is of the Alden

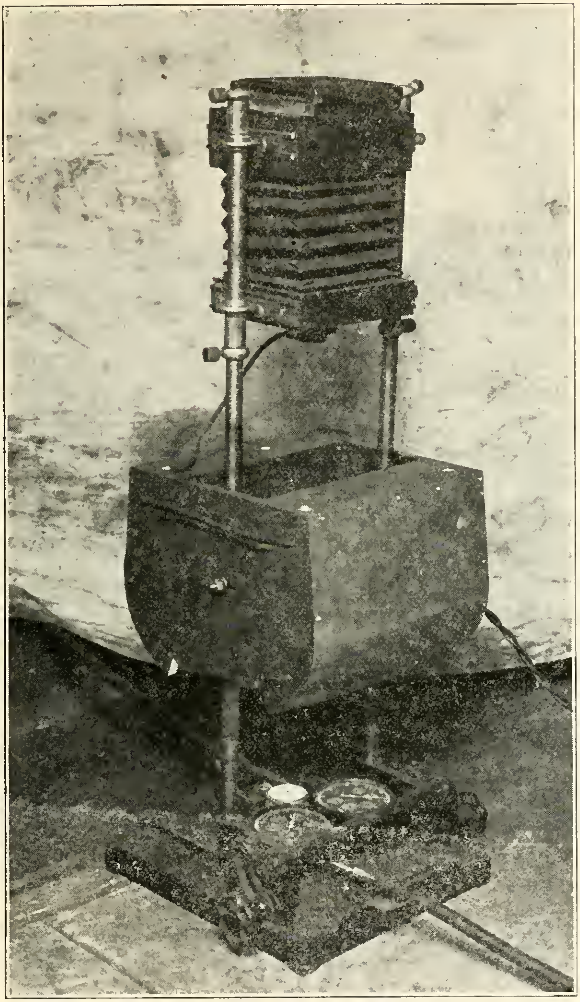


Fig. 2. Belt Testing Machine.

dynamometer type, and the load required to absorb the power is controlled hydraulically from any convenient point.

The speed of the dynamometer is transmitted through flexible shafting to a special tachometer so arranged that the index needle moves axially across the paper drum. The intersection of the tachometer index with that of the torque index gives the horsepower directly. Thus a glance at the meter proper gives the

load on the scale in pounds, the torque in foot-pounds, the speed of the dynamometer in revolutions per minute, and the horsepower developed at the rear wheels. The scale beam offers a check on the float mechanism, and a small set screw in the body of the oil chamber permits adjustments to be made for any temperature variation therein.

Belt Testing Machine: The unusual feature of this device lies in the method of speed measurement. The horsepower input and output, total tension and stretch are obtained by the usual laboratory appliances, though attention should be called to the use of an electric cradle dynamometer for measuring power input, and the liberal use of ball bearings for eliminating sliding friction. The speed of the driving and the driven pulley, slips and creeps of the belt are measured photographically. Two continuous speed counters, connected by flexible shafting to the driving pulley and driven pulley respectively, are mounted together with a split-second watch under a long focus camera. By means of a number of nitrogen filled lamps sufficient illumination is effected to photograph the counters and watch in one twenty-fifth of a second. By comparing the photograph taken at the beginning of the run with that at the end, the total number of revolutions for each counter and the elapsed time to one-fifth of a second may be readily obtained. The counters and watch operate continuously, so that no contact mechanism, releases, or clutches are necessary when beginning or completing a run. A difference of one revolution in 30,000 per unit of time is obtained with the same degree of accuracy as one in fifty.

Thermal Conductometer: This is a particularly accurate instrument designed for measuring the heat flow through materials such as are generally used in cold storage construction. Among such materials may be mentioned cork board, mineral wool, lath, rock cork, etc. The instrument may be used to measure heat flow through any material that can be prepared in flat slabs or plates. It consists essentially of three flat plates, each approximately 18 inches square. One is provided with a winding of resistance ribbon distributed uniformly over the surface, through which a current of electricity may be passed to heat the plate. The other plates are made hollow and are kept cool by circulating water through them.

When the instrument is in use, the hot plate is set up in a vertical position with a cold plate on each side. Two samples of the material to be tested are prepared and placed one on each side of the hot plate between the latter and one of the cold plates. Thus the heat generated in the hot plate passes through the test material on both sides and into the water-cooled cold plates.

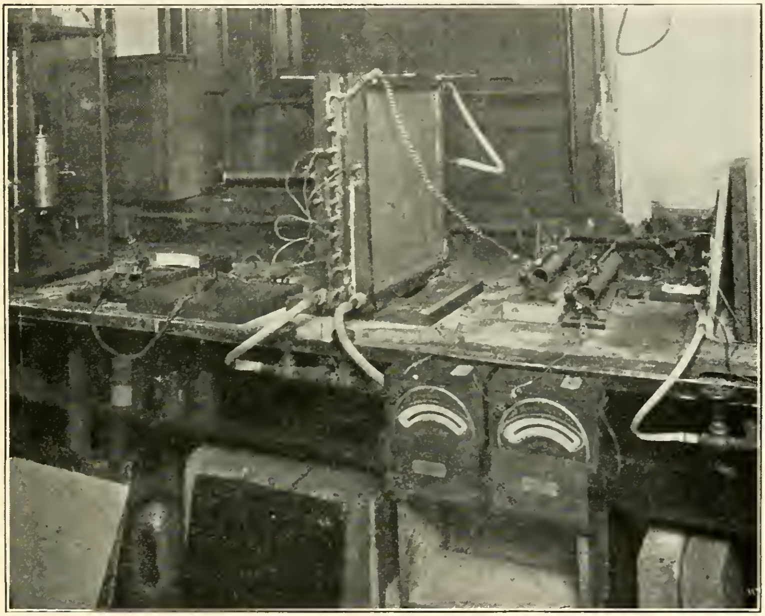


Fig. 3. Thermal Conductometer.

From the resistance of the winding on the hot plate and the current used the heat input is readily calculated. The temperature difference between the hot plate and the cold plate is measured by copper-constant thermocouples connected to a portable galvanometer. Thus since the rate at which heat is given off per unit surface on the hot plate is known, and also the temperature difference between the hot plate and the cold plate, the heat passing through the material per degree of temperature difference is easily determined.

Oil Friction Machine: In basic principle this device is similar to the "Thurston Railroad Oil Tester" but differs considerably in detail. It is capable of measuring friction loads as high as 700

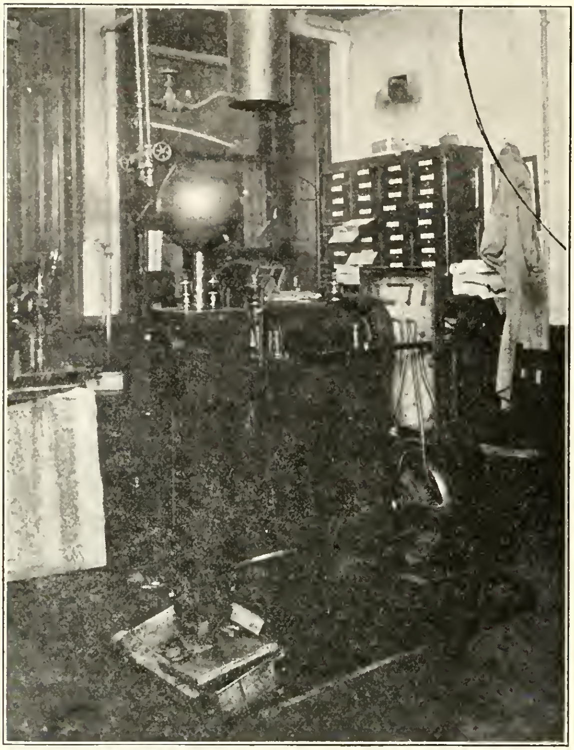


Fig. 4. Oil Friction Machine.

lbs. per sq. inch of bearing surface. The boxes surrounding are jacketed so that any uniform temperature ranging from —20 deg. F. to 400 deg. F. may be maintained. For the lower temperatures refrigerated brine is circulated through the jackets and for the higher ranges high pressure steam is used. With this device it is not necessary to establish thermal equilibrium between bearing friction and heat dissipation from the machine, as is the case with unjacketed oil friction machines. Total pressure, speed, and temperature may be varied independently.

Ball Bearing Friction Machine: This machine (Fig. 5) differs from that ordinarily designated for this purpose in that both radial and end load friction may be determined simultaneously or separately. The various levers exerting pressure on the bearings are so proportioned that one set of weights suffices for all

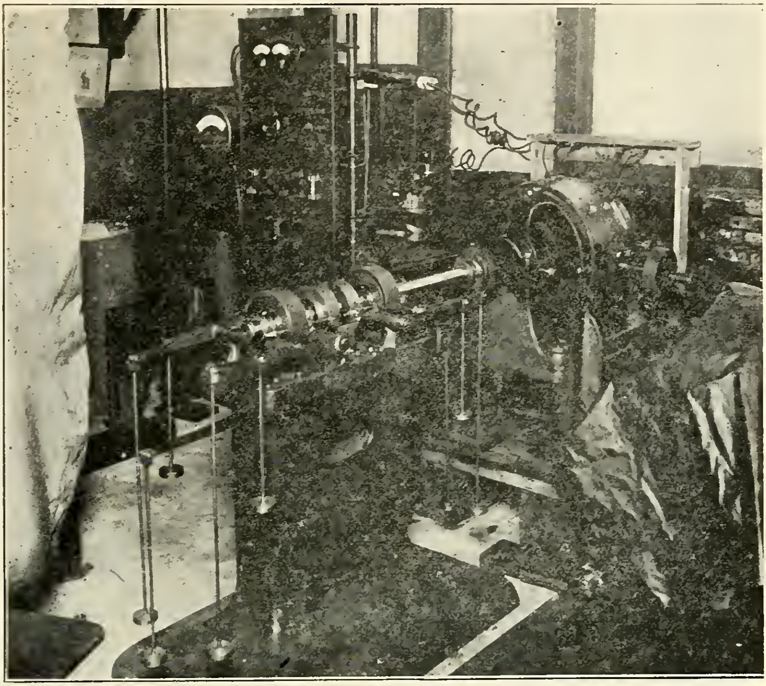


Fig. 5. Ball Bearing Friction Machine.

conditions of loading. The device consists essentially of four ball bearing cages (two rigid and secured to the frame and two floating but constrained against rotation) fitted with bearings and riding on a special heat-treated shaft. The radial load is applied to the bottom of the two center cages, and since all bearings are equal distances apart, this radial load is uniformly distributed over each bearing. The end loads are applied through the agency of suitable levers to the bearing cages in such a manner that all end thrusts are obviated except those incident to the bearings themselves. The shaft is free to move axially, and the power absorbed in overcoming friction is measured by means of a sensitive electric cradle dynamometer. The entire construction is such that only the friction of the bearings is measured by the dynamometer.

Boiler Control Board: In the boiler room the instrument board is of interest. It is plainly visible to the fireman when

operating the boiler and contains only indicating instruments, as the recording elements are located in the engine room. This board enables the firemen to note the flow of steam, flow of feed water, flue temperature, steam pressure, draft pressure drops through fuel bed, furnace, and boiler, and the percentage of CO_2 in the flue gases at any instant. In this respect it differs in no way from a number of test boards in general practice. The dis-

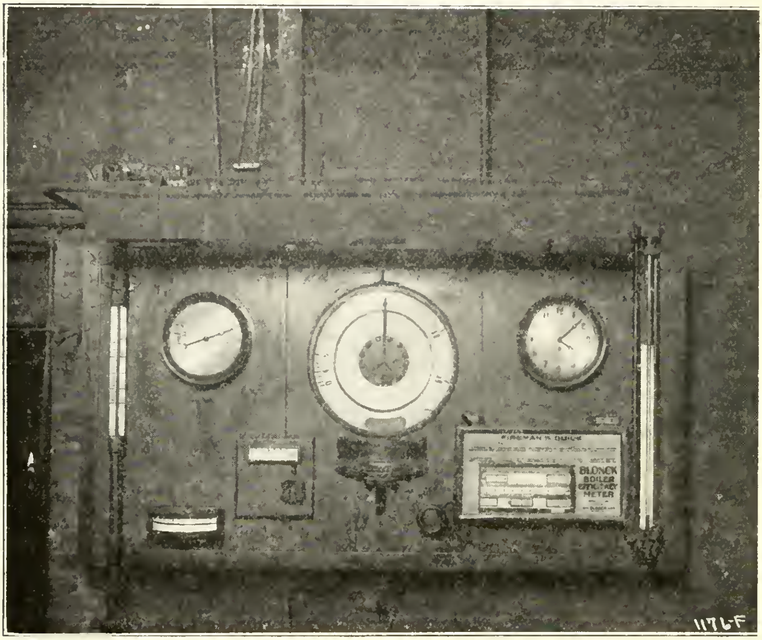


Fig. 6. Boiler Control Board.

tinguishing features lie in the addition of a control valve, adjacent to the draft gages, for opening and closing the boiler damper, and a fuel counter. By turning the handle of the control valve the opening of the damper may be regulated to suit conditions, and the effect is at once visible on the draft gauges. An indicating needle, in plain view of the firemen but not mounted on the board, shows the amount the damper is open. Since the coal burned is a washed nut of uniform size, the height of the coal gate and the speed of the chain are direct functions of the weight of coal burned. Thus an ordinary electric counter, actu-

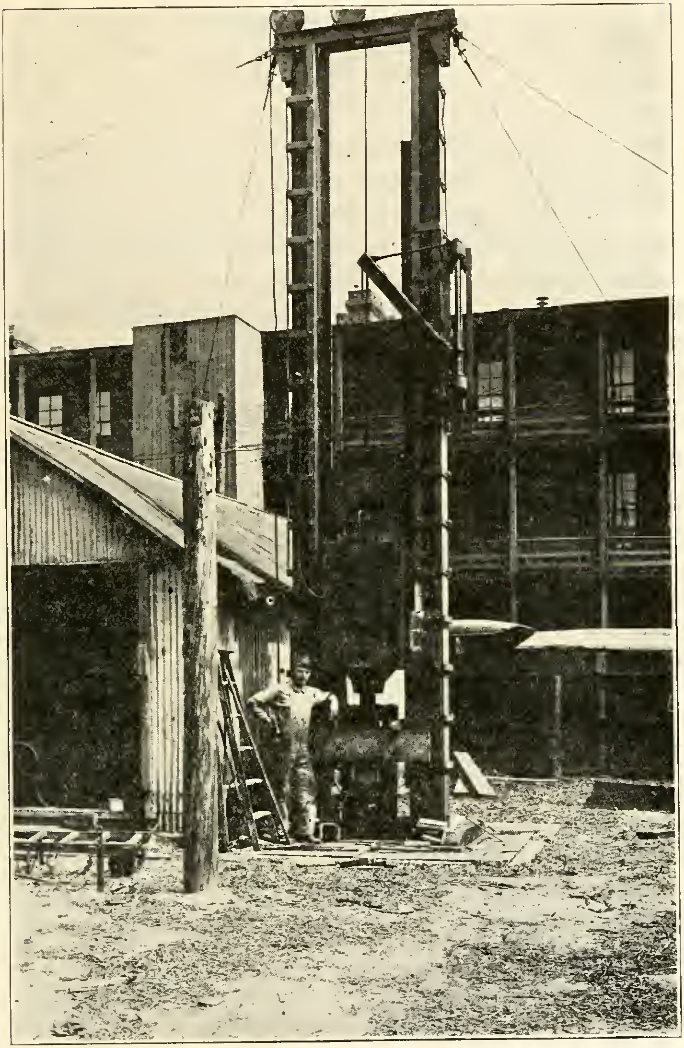


Fig. 7. Impact Machine.

ated by the driving gear of the chain grate and calibrated for the given size of fuel and gate opening, records the weight of coal fired. Numerous tests show a maximum error of only 2 per cent between the counter readings and the fuel as actually weighed. A special tachometer has just been constructed which

will show the rate of combustion, pounds of coal per hour and per square foot of grate area per hour at any instant. They will be mounted on the board and will take the place of the present counter.

Impact Machine: This is one of the few machines of large size in the country. The top is a simple steel casting weighing 9000 lbs. and having a maximum drop of 20 feet. It is lifted by an electromagnet actuated by a 10 horsepower motor. This device is used primarily for determining influence of impact on heavy railway appliances, such as draft gears, springs, knuckles and the like.

A. S. M. E. ORGANIZES MATERIALS HANDLING SECTION

Four hundred members of the American Society of Mechanical Engineers have organized themselves into a "Professional Section on Material Handling," and will provide primarily a common channel of intercourse between all the technical and industrial organizations co-operating in the solution of engineering problems connected with the handling and distribution of materials and products.

This section will aim to be a bureau of information—complete in its scope, specific in its knowledge of the physical and economic conditions, and unbiased in its conclusions.

A NEW FACTORY.

By P. G. Odgers.

The outlook for the future of American industry is indeed promising due to the fact that the policy adopted by a large number of industrial leaders has in recent years been shaped so as to include a "square deal" for the employees, and the best that architecture can provide in the way of buildings and grounds, designed and constructed to suit each particular business, and to reduce to a minimum the cost of production and handling of goods.

Among these is the plant of Bunte Brothers, now under course of construction on one of the principal thoroughfares of the west side of Chicago. The site is an ideal one for a business such as will be housed here. It covers an entire block, while the principal street, the one on which the building faces, is a magnificent boulevard of exceptional width. The parkways flanking the boulevard contain beautiful trees, an asset which in some localities takes many years to acquire.

The plant consists of the main building, occupying an area of 75000 square feet, with provision for ample extension in the future. Directly to the rear is a power house containing the last word in equipment. The power house is adjacent to the main division of a large railroad, and switch tracks from the main building and the power house connect with this railroad.

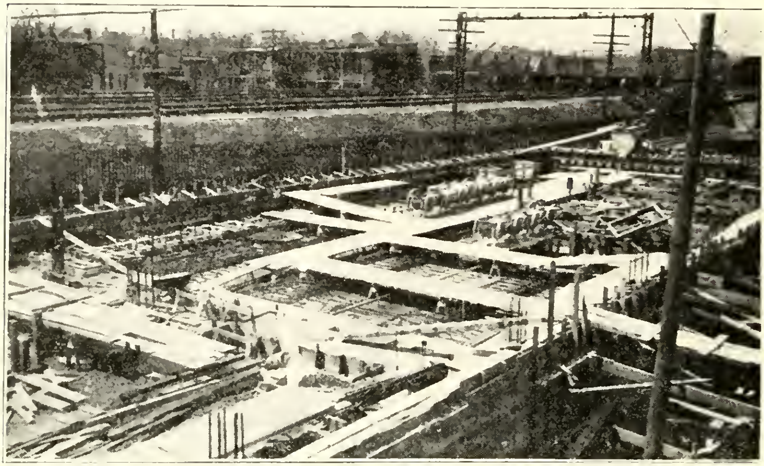
The building, plans of which were prepared by Messrs. Richard E. Schmidt, Garden, and Martin, architects, and Mr. T. W. McNeill, mechanical engineer, is so designed that all the requirements for this particular business have in every way been satisfied, and the future development of the plant can proceed at any time without interference or disarrangement to the present project.

The main building in plan is T shaped, the stem of the T being at right angles to the principal street, and includes four stories and basement, with a square tower over the front portion of the central wing, extending five stories above the roof of the main building.

The main building is fireproof throughout and of skeleton construction, the structural parts being of reinforced concrete. In the construction of the floors the S. M. I. system of flat slabs

was used, and with a spacing of interior columns of 20 ft. 6 in. center to center, it gives to the working space a maximum clear story height as well as the greatest possible unobstructed area.

The exterior design bears a dignified appearance of pleasing proportion and lines. The keynote of the facades are the projecting brick piers which enclose the structural columns.



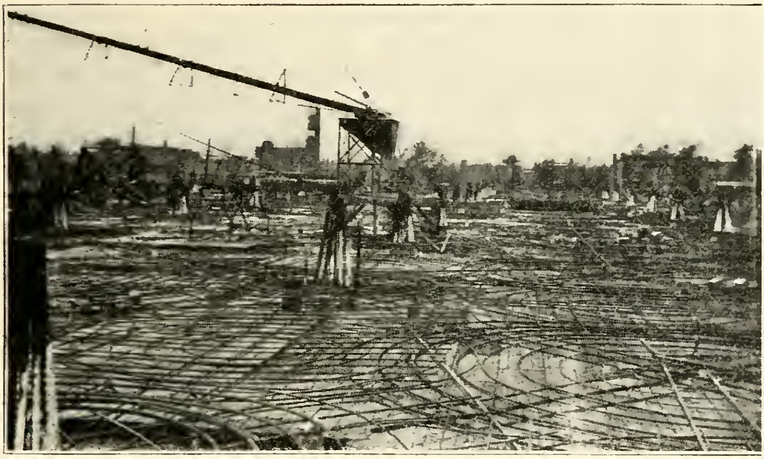
This scheme carries a utilitarian purpose in that it leaves the interior wall surfaces flush, with no columns projecting into space which can be used to advantage. In this particular instance it allows of the use of a number of horizontal conveyors extending along the exterior walls, with no space lost between conveyors and wall surfaces.

The exteriors include the use of pressed brick of rich texture and trim, and belt courses of limestone. These two materials are so arranged that no concrete is exposed on the exterior with the exception of a small base around the shipping platforms at the rear of the building. In general the window openings extend the full distance between the brick piers and in height nearly to the ceiling line. The openings are provided with pivoted steel sash, giving a maximum amount of light and ventilation to the interior.

The main entrance, which faces the boulevard, together with the projecting bays at each side of the tower, is worthy of special

comment. The entrance is flanked by two large brick pylons extending nearly the full height of the building and surmounted by large stone carved eagles of exceptional character. These are in turn recalled on each side by pylons of smaller dimensions topped by carved stone panels, which support carved eagles similar in character to one on the pain pylon.

A very brief description of the disposition of the various floors will explain the method of manufacture and arrangement of the several departments.



The basement contains locker rooms and rest rooms for persons employed in the general offices located on the first floor. These units are located in the front portion of the principal wing of the building. Directly to the rear of these units are located the lunch rooms, there being separate lunch rooms for male and female employees. Adjacent to this department are the kitchens, equipped for serving a substantial luncheon to the employees. The balance of the central wing contains the employment department, together with the medical and first aid units. They surround a spacious lobby which provides ample access and egress to and from the various departments on the floor above. The remaining portion of the basement contains storage space and is accessible from the adjacent switch track: thus goods can easily be received from cars and trucks.

The first floor as stated above, contains the general offices. This space surrounds a large central lobby, a portion of which will provide a space for the display of merhcandise. Directly to the rear of the general offices is located the main stock room, which serves both the city and country shipping rooms. The department for city jobbers is also located on this floor at the rear of the building. This department is complete in itself, having its own bookkeepers, display space, shipping room, etc.

The upper floors are given over entirely to manufacturing. The process is what is termed the gravity methed. The goods started at the top floor are sent from one department to another always in a downward direction until completed, when they are ready for the stock room or immediate delivery. The various departments are so related as to reduce to a minimum the travel and handling of the goods which in merchandise of this character is of utmost importance.

The tower contains various storerooms and space not yet assigned for a particular purpose. The top floor of the tower contains elevator pent houses, etc., with a large house tank and two large sprinkler tanks of 50,000 gallons capacity each.

The power and heat for the plant are provided in the power house, the present generators having a capacity of 2000 H.P. with provision for two future units. Adjacent to the power house and connected thereto is a deep well supplying pure water to the whole plant. Fuel and ashes are handled mechanically and there is a complete system of underground tunnels for pipes, wires, etc., that extend from the power house to the main building, and also to a garage already completed and located across one of the side streets from the main building.

In conclusion it is safe to say that one will travel long and far before one observes a plant where the requirements of the particular business have been so successfully dealt with. When fully completed it will be a permanent monument to the wisdom of the owners and a place of contentment to the employees who are housed in it.

THE TREND OF MODERN INTERCOLLEGIATE ATHLETICS.

By Joseph Schommer.

When asked to write an article pertaining to athletics at Armour not long ago, the instructions were to write in the usual strain, which involved spirit, loyalty, and the desire to win, in order that it might awaken students to go out for the "Tech Teams."

The following article deviates from the beaten paths generally adopted. Statistics are tabulated and it is hoped all who chance to read this article may champion the cause of physical development. The facts are self evident and are beyond dispute.

PHYSICAL DEFECTS AS SHOWN BY DRAFT FIGURES

I. *Material for Reference.*

Reference material for students who wish to study the question of physical defects in men drafted for service in the world's war may be obtained from the following:

1. First report of the Provost Marshal General.

2. Second report of the Provost Marshal General.

3. Report of the Surgeon General of the U. S. Army to the Secretary of War, 1919.

4. Bulletin number 11, March 1919, War Department, Office of the Surgeon General.

5. The war with Germany—by Col. Leonard P. Ayres, chief of the Statistics Branch of the General Staff.

6. Defects Found in Drafted Men, Printed for the use of the Senate Committee on Military Affairs. Most of these books may be obtained free by writing for them.

The following items are taken from the foregoing books. The writer has attempted to select the basic facts from these publications and to list them for the Use of Physical Educators.

II. *Preliminary Statistics.*

1. At the outbreak of the war the total male population of the country was about 54,000,000.

2. Before the war ended 26,000,000 males were either registered under the selective service act or were serving in the army or navy without being registered.

3. There were about 200,000 commissioned officers in service. Of these 5,791 were regulars.

4. Four million, eight hundred thousand men served in the armed forces of the nation during the war. Four million were in the Army.

5. The average soldier who went to France received six months training in this country.

6. The death rate from disease in the Mexican War was 110 per year for each 1,000 men; in the Civil War, 65; in the Spanish War, 26; in the A. E. F., 19 per thousand.

7. Of each 100 cases of venereal disease recorded in the United States, 96 were contracted before entering the army and only 4 afterward.

III. *General Statistics.*

1. In round numbers, 29.59% of the men examined by the draft boards were partly or totally disqualified.

2. The Army surgeons rejected 5.32% for all military service at the mobilization camps.

3. It is safe to say that 55% of the men examined had defects serious enough to interfere with the performance of their full military duties.

4. In some states over 50% of the men of military age were defective.

5. About two-thirds of the recruits sent to camp were found to be without noteworthy physical defects.

6. Flat foot is the greatest defect noted; it was found in nearly one-fifth of the men examined.

7. Defective physical development was found in the New England States in exceptionally high proportion.

8. Simple goiter was strikingly common in the territory adjacent to the Great Lakes.

9. Men from the cities showed about 30% more defective vision than men from rural districts.

10. Hernia was found somewhat more commonly in recruits from cities than from rural districts.

11. Flat foot is markedly more common in recruits from the cities than in recruits from the rural districts.

12. There was a preponderance of city-reared young men who were rejected for under-weight.

13. The office in charge of the sanitary division of the surgeon-general's office estimates that the average gain in weight in the first year of military life was from 15 to 20 pounds.

14. Out of 2,753,922 examined, there were found 468 defective men per thousand examined. This means that nearly half of the men examined showed a defect worthy of notation.

15. Fully half of the defects found are not of such a nature as to interfere seriously with the man performing services of a high order in civil life.

16. The occupations play a role in the distribution of defects. Bad postures at school, especially in the badly nourished and rickety children, account for much of the curvature of the spine, and walking on pavements in tight shoes accounts for many of the bad feet of city folk. Much school and clerical work tend to induce myopia in those so disposed. Straining the body by heavy work induces hernia. Agriculturing is associated with good eyes and straight backs. The commutor group represents the physically fittest of the population of the eastern section of the country.

17. 100,000 country boys would furnish for the military service 4,790 more soldiers than would an equal number of city boys.

18. 100,000 whites would furnish 1,240 more soldiers than would an equal number of colored.

19. 100,000 native-born would furnish 3,500 more soldiers than would a like number of foreign-born.

IV. *Chart of Defectives.*

1. Explanation. In the first column the total diseases per thousand is listed. That is, if one man had three defects serious enough in character to be noted, each defect is noted. In the second column, the number of defective men per thousand is listed. If a man had two or more defects, they are counted as one. The third column lists the total rejection per thousand by states, while the fourth column lists the number of defective men who were accepted for service. The fifth column lists the number of men per thousand who were defective because of physical development. That is, they were under size, over size, small chested, etc. The last two columns list the number per thousand who were venereal or had eye defects respectively.

CHART OF DEFECTIVES.

States	Total Diseases of defects for U.S. by states	Total defective men by states	Total rejections by states	Total Def. men for class A, B or C	Defective Physical Development	Total Venereal	Total Eye Defects
Rhode Island	802.03	640.48	424.42	342.52	112.51	27.56	72.70
Vermont	763.76	613.19	353.93	365.77	63.33	13.03	66.19
Virginia	734.08	604.21	245.57	445.22	33.05	72.21	36.60
Oregon	721.95	579.59	219.79	428.50	27.18	22.28	39.81
Maine	705.63	568.61	346.00	305.54	73.10	23.74	66.08
California	689.55	583.89	265.01	394.45	45.91	27.58	42.78
Colorado	679.40	544.97	213.50	405.84	34.81	24.60	34.90
Florida	675.87	541.60	199.84	390.34	44.11	163.32	33.25
Washington	665.99	549.41	262.78	361.42	29.31	28.93	39.22
Massachusetts	648.03	535.80	267.26	334.73	64.58	23.58	69.75
Wyoming	635.36	514.32	128.05	414.30	19.44	23.37	30.14
West Virginia	620.04	507.38	177.60	381.90	17.15	52.67	36.81
Maryland	619.45	526.20	244.25	367.08	43.43	66.73	53.36
New Hampshire	617.49	505.28	203.05	347.13	59.16	18.49	50.39
Utah	613.99	505.82	219.27	339.15	32.46	19.38	34.74
Pennsylvania	603.48	500.00	209.31	358.50	32.77	36.48	42.61
Connecticut	600.84	507.89	226.61	331.03	39.32	26.55	70.86
New York	594.23	502.70	240.40	325.68	36.20	29.77	62.74
Missouri	589.35	489.00	206.90	336.49	34.75	65.24	38.85
Wisconsin	582.12	465.03	200.38	312.83	28.85	20.28	41.47
Idaho	570.55	479.26	179.63	339.30	21.86	22.45	33.14
Nevada	566.22	476.00	186.03	328.09	32.51	32.96	37.37
Michigan	560.57	467.20	233.12	280.79	22.52	44.54	40.36
Illinois	552.81	471.25	202.48	325.64	28.65	52.69	43.18
Delaware	550.15	475.18	198.00	326.77	57.76	77.21	29.87
No. Carolina	545.91	453.89	213.40	278.27	33.41	69.56	31.58
Tennessee	542.90	442.40	245.60	251.94	52.51	65.16	39.85
New Mexico	542.47	458.22	206.61	303.00	34.80	67.43	39.49
Georgia	540.40	455.78	225.14	276.55	48.79	135.64	33.43
Montana	532.44	465.70	162.67	324.78	15.86	34.49	33.73
New Jersey	525.26	452.30	208.93	295.19	35.10	34.99	43.11
Louisiana	522.96	438.90	239.05	244.51	37.22	121.40	35.57
No. Dakota	520.57	438.60	167.01	315.93	12.88	18.64	34.77
Mississippi	517.90	425.21	199.78	258.76	24.74	132.46	32.25
So. Carolina	511.99	422.60	222.49	232.85	42.79	131.32	23.84
Oklahoma	508.68	432.70	184.93	291.80	23.31	85.15	33.11
Iowa	506.92	425.78	204.08	266.16	30.11	29.87	33.68
Minnesota	502.54	420.50	189.69	277.91	22.48	24.20	33.29
Indiana	501.20	416.99	183.47	275.85	29.27	47.07	35.77
Alabama	500.12	427.70	179.60	281.45	29.57	114.67	25.82
Ohio	497.45	421.40	187.88	277.87	25.46	41.34	33.52
Arizona	467.51	410.61	153.29	290.17	15.19	48.20	20.25
Texas	466.66	402.40	175.90	266.79	28.74	112.08	31.39
Arkansas	460.75	384.20	163.90	244.11	26.16	105.28	32.47
Kentucky	454.63	382.10	207.26	208.04	42.62	39.53	36.36
Nebraska	446.72	386.99	134.64	283.80	15.67	30.97	28.59
So. Dakota	442.75	373.20	187.59	221.21	16.89	15.60	34.95
Kansas	422.39	354.35	147.29	232.04	160.69	30.07	28.79

After thoughtful study of the above statistics there is but one conclusion to arrive at in studying the system for physical development as tolerated at most colleges.

The benefits are for a few.

The student body but for a small number is neglected.

No system for training men physically is any good but that one which forces every student in some sort of athletic participation. This is being recognized in some institutions and systems of intermural sports and mass athletics are being adopted. These systems provide for the participation of every student in some branch of athletic games.

However, where educational institutions attempted mass athletics and intermural sports without the system of competition with other colleges in such branches as baseball, track, basketball, football, etc., the plan was a failure. A stimulus seemed to be lacking. The desire to win a college letter is always strong and where intermural sports and competitive athletics were participated in together, the entire student body was always interested.

Some of the big eastern and western universities have adopted mass competition and international sports with competitive athletics, with such success, that in the next ten years sweeping changes will be seen everywhere in college athletics. Instead of a few, every student will enjoy the advantages of competitive games and with skilled men be cured of stoop shoulders, flat feet, curvature of the spine, etc., in a corrective gymnasium course.

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ENGINEERING PERSONALITY.

"It was not his remarkable power of diagnosis," said the speaker, referring to a famous physician, "nor was it his intimate knowledge of the technicalities of his profession that made his reputation. It was the fact that somehow, whenever he entered a sick room, his very presence seemed to restore peace and calm. The personality of the man entered every corner, and disorder fled at his approach."

A physician and an engineer are similar in these respects: both are professional men; both must have detailed knowledge of their field; and both must be able to convince their clients of their ability.

Does the engineer, in his dealings with his associates, possess that same personal power as the physician above? When he enters a directors' meeting to present a practical theory, does he spread a confidence in his ability by his personal bearing? Do men say as he enters the room, "There is a man who surely knows"?

Such a power is sometimes known as personal magnetism, and it cannot be gained by either reading or study. It is an art, rather than a science, and can be perfected only by constant practice and by that daily growth which comes as a result of analyzing past mistakes to improve present actions. It combines an intimate knowledge of human nature with an appreciation of the "eternal fitness of things," and is one of the most valuable things that any man, engineer or otherwise, can possess.

Like an art, however, personality can be aided and developed by an intelligent study of the factors involved. Some of these are breadth of view, distinction, learning, influence, and dignity. The engineer who wishes to develop this side of his education, can do well to familiarize himself with books on logic, psychology, self-analysis, salesmanship, and public speaking. He should take advantage of every opportunity of mixing with his fellow men, especially with those older than himself. They have often experienced both failure and achievement in life, and are in a position to give much valuable advice.

"The entire object of true education is to make people not merely do the right things,—but enjoy the right things—not merely industrious, but to love industry—not merely learned, but to love knowledge—not merely pure, but to love purity—not merely justice, but to hunger and thirst after justice."—*Ruskin.*

THE THINKER.

By Berton Braley.

Back of the beating hammer
  By which the steel is wrought,
Back of the workshop's clamor,
  The seeker may find the Thought,
The Thought that is ever master
  Of iron and steam and steel,
That rises above disaster
  And crushes it under heel.

The drudge may fret and tinker
  Or labor with lusty blows,
But back of him stands the Thinker,
  The clear-eyed man who knows;
For into each plow or sabre,
  Each piece and part and whole.
Must go the brains of labor
  Which give the work a soul.

Back of the motors humming,
  Back of the belts that sing,
Back of the hammers drumming,
  Back of the cranes that swing,
There is the eye that scans them
  Watching through stress and strain,
There is the Mind that plans them,
  Back of the brawn—the Brain.

Might of the roaring boiler,
  Force of the engine's thrust,
Strength of the sweating toiler,
  Greatly in these we trust,
But back of them stands the Schemer,
  The Thinker who drives things through,
Back of the Job—the Dreamer.
  Who's making the Dream come true!

SPARKS FROM DR. GUNSAULUS' LECTURES.

"We know that wisdom is not easily found. It is hidden beneath the literature of the ages, and we must mine for it."

"An alloy lasts longer than the pure metal. The poetry or fire is the alloying material in prose which has made it last thru the ages."

"These are people who are the very incarnation of piety. They stand ever so vertically, but they cannot bend. They break like pipe-stems."

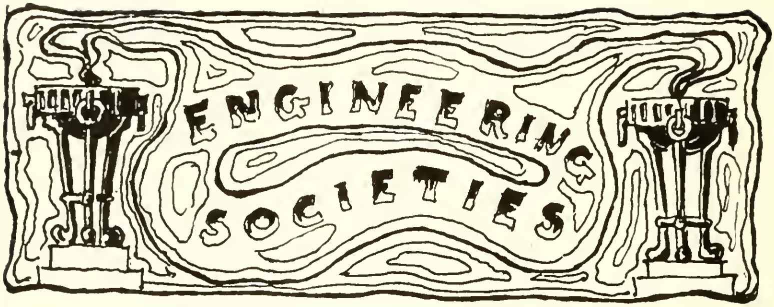
"I'm along in life. I've got nothing but the dump. I've been mining forty years for truth, but an entirely new process can relieve as much gold again from my ore. The wisdom of the hour is ready for the new process. Use it."

"I don't mean common sense, which is the most uncommon thing in the world."

"The larger the circle of light in which you stand in the center, the larger the outlying circle of darkness."

"Don't believe it because it's in the book, but respect the book because it's there. It is in the book because it's true."

"Civilization is togetherness. It is the association that you can rely on as one."



THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Charles T. Walter .... *President*
John P. Sanger .... *Vice-President*
Robert W. Van Valzah .... *Treasurer*
William A. Heitner .... *Secretary*

The first meeting of the Mechanical Engineering Society of the Armour Institute of Technology was held in Machinery Hall on October 8, 1920.

After the election of the officers for the year, steps were taken to help the Junior Branch of the A. S. M. E. organize.

It was decided that the organization give the customary "Annual Smoker" as soon as possible, for the purpose of bringing together all of the mechanical students of the College and helping them to become acquainted with those of the Faculty, who always lend a helping hand to the mechanical students.

The second meeting was held on October 21, 1920. This was the first "big" meeting and was a very great success.

Prof. Gebhardt gave an address in which he outlined the object of the society, which is to enable men to talk before an audience, using good English, and to overcome self-consciousness. He further stated that an organization, called the Federated American Engineering Society, is being formed with the purpose of establishing a code of ethics for the engineer which will prevent an engineer from doing any work, which is not in every respect in accordance with the best practice.

Prof. Gebhardt also brought to our attention the importance of the engineers entering into public life in order to help bring to him the recognition which is due him, but which, to the present date, the engineer has been too modest to demand.

President Walter then called on Mr. Wm. A. Heitner to give a talk. Mr. Heitner's subject was "The Starting Up of the Ball and Wood Engine of the Main Power Plant of the Institute and Changing Over on the Switch Board." The object of this talk was to outline and explain the different operations, so that the mechanical students could become more familiar with starting up a unit. He attempted to pave the way so that, when the different members actually perform these operations as a mechanical laboratory experiment, they would more readily understand the reasons for the various steps taken.

The following schedule of meetings was adopted:

Oct. 21, 1920—	Thursday	10:30—11.30
Nov. 3, 1920—	Wednesday	10:30—11:30
Nov. 17, 1920—	"	10:30—11:30
Dec. 1, 1920—	"	11:30—12:30
*Dec. 15, 1920—	"	10:30—11:30
Jan. 12, 1921—	"	10:30—11:30
Jan. 26, 1921—	"	11:30—12:30
Feb. 9, 1921—	"	10:30—11:30
Feb. 23, 1921—	"	11:30—12:30
Mar. 9, 1921—	"	10:30—11:30
Mar. 23, 1921—	"	11:30—12:30
Apr. 6, 1921—	"	10:30—11:30
Apr. 20, 1921—	"	11:30—12:30
*May 4, 1921—	"	10:30—11:30
May 18, 1921—	"	11:30—12:30

(*) Meeting of all mechanical students of the Institute.

WM. A. HEITNER,
Secretary.

ARMOUR BRANCH OF THE WESTERN SOCIETY OF ENGINEERS

President..............................R. M. Singer
Vice-President......................G. C. Kumbera
Secretary ....Vacant
Treasurer........... ....G. W. Peterson

The first meeting of the Armour Branch of the Western Society of Engineers, this year, was held in Room D in the Mission Building, Oct. 5, 1920, P. M. The regular business was dispensed with and was followed by a few pointed remarks by Profs. Phillips and Penn.

The next meeting took place in Room B, Mission Building, Oct. 22, 1920, P. M. At this meeting the resignation of our Secretary, W. K. Lyon, was read and accepted. We were very sorry to lose so good a man. It will be difficult to find a man to fill this important office.

After the meeting the members were entertained by an illustrated lecture on "The Aesthetics of Bridge Design," given by Prof. M. B. Wells of the Civil Department. The subject matter was very interesting and skillfully handled.

Up to the present time we have made a number of interesting and instructive inspection trips. The following places were visited:

Michigan Ave. Bridge,
Franklin-Orleans St. Bridge,
Wells St. Bridge,
Three Water and Sewage Pumping Stations
Sag Canal at Blue Island,
A fifteen Foot Intercepting Sewer,
City Bridges, Breakwater and Cribs,
Lockport and Joliet Power Plant,
Controlling Works of the Sanitary District at Lockport.

The outlook of the Armour Branch of the Western Society of Engineers for the coming year is very bright.

A. I. E. E.

The first meeting for 1920-1921 of the Armour Branch of the American Institute of Electrical Engineers was held on Tuesday, Oct. 26, 1920. Forty seniors, juniors and sophomores were present and elected W. W. Pearce as temporary chairman.

Professor Freeman started the meeting with a ten minute speech on the value of the A. I. E. E. to students of electrical engineering. Prof. Snow followed with an informal talk in which he strongly recommended that the local branch meetings be made opportunities for men to train themselves in speaking on both prepared and impromptu talks, besides being places for the transfer of technical knowledge or, shall we say, information. Mr. Malwitz supported Prof. Snow's recommendations, and in addition, outlined the practical value of membership in the national organization, with particular reference to the articles appearing in the proceedings, as published by the national organization.

After the election of officers for the coming year, the subject of programs for the future meetings was further discussed. It was decided that talks by the student members themselves could be of more value than a few longer addresses by graduate members.

The chairman was given authority to appoint a number of men to speak at each meeting on assigned or chosen topics as the requirements were felt; each man to speak ten or fifteen minutes, and each paper to be followed by an open discussion.

The officers elected for the year are:

Chairman—R. C. Malwitz.

Secretary—T. L. Albee

Treasurer—W. W. Pearce.

After an unsuccessful attempt to set a time for the next meeting that would be agreeable to all, the matter was left to the discretion of the chairman, and the meeting adjourned

ARMOUR CHEMICAL ENGINEERING SOCIETY

The first meeting of the Armour Chemical Engineering Society was held October 6, 1920, and the following officers were installed:

President .... Winter
Vice-President .... McCaffery
Secretary .... Savoye
Treasurer .... Albeck

Among the activities of the following year, the society has planned a series of lectures along chemical lines. These lectures will be given when possible at four o'clock on Tuesdays.

The full list of lectures to be given, and the dates thereof, will be published in another issue.

THE ARMOUR ARCHITECTURAL SOCIETY

The class of 1921 has had a rather unfortunate college career because its four years extended thru the war and reconstruction period. Now, in its fourth year, it seems that conditions are such that its members may again indulge in activities that gladden the heart without being out of harmony with the times.

The society which probably felt most keenly the restrictions of the relentless "Mars," was the Armour Architectural Society. This year they expect to go back to pre-war activities and pre-war pep. The freshman class is unusually large, which means that the sophomores will have ample opportunity to pass on at the initiation with interest, those things which are fitting and proper at such an affair. At the close of the ordeal the new members of the society as well as the old, will make merry over a repast furnished by the refectory, while discussing the plans and aspirations of the club. Prominent speakers will unfold to the aspiring architects the secrets of their profession, and last, but not least, the evening will be shortened by the Architects' own Jazz Band. The members will then disband and go home to dream of becoming second Louis Sullivans or Bertram Goodhues.

THEODORUS M. HOFMEESTER,
Massier.

ARMOUR RADIO ASSOCIATION

The first meeting of the Armour Radio Association was held on Sept. 29, 1920, for the purpose of electing officers for the coming year. A total of sixteen radio enthusiasts responded to this first "Q. S. T." The officers of the association, elected at this first meeting, are:

President........... ....E. A. Goodnow
Vice-President........................V. L. Cooley
Chief Operator......................H. L. Hultgren
Secretary...........................R. S. Kenrick

The purpose of the association was clearly set forth in a short talk given by Professor Wilcox, for the benefit of the new members. The primary purpose of the Association is the stimulation of interest in all radio matters among not only station operators, but also among others who may be interested. Professor Wilcox also called attention to the mutual benefits to be derived by the members of the association through free discussion of any perplexing problem confronting any member.

The special experimental federal radio station license (call letters 9YL) just recently received from the local radio inspector, was exhibited at this first meeting. This lengthy document permits, under certain specified conditions, the operation of a transmitting station by a duly licensed operator over a limited range of wave-lengths.

The second meeting of the association held on October 13, 1920, was devoted largely to radio code practice. Chief Operator Hultgren officiated at the key, in characteristic commercial fashion, for the benefit of the members who wished to take advantage of the valuable opportunity offered.

The third and last meeting of the Armour Radio Association was held October 27, 1920, in the Physics lecture room. Mr. A. R. Mehrhof gave an illustrated talk on the Institute station, designed and built last year under the guidance of Mr. H. D. Stevers, our past president. The station is located on the second floor of the Physics Laboratory (Chapin Hall) and is equipped with two antennaes. One is a long wave receiving aerial, consisting of a single wire about one hundred feet long, running diagonally northeast from the station, and the second is a short two hund-

red meter transmitting aerial, designed for use with the spark transmitter. The directive characteristics of the long wave receiving aerial make it very efficient for long wave European reception. Equally satisfactory results are obtained, however, in a westerly direction, the Philippine Islands being heard from on one occasion, as Mr. Mehrhof testified. Circuit diagrams of both the transmitting and receiving set were projected upon the screen for the benefit of everyone interested in the operation of the school station. In addition to the excellent results obtained in undamped wave reception the speaker pointed out several instances of exceptional results obtained in six hundred meter spark reception.

A very interesting talk on the amplification constant of vacuum tubes was given by Mr. G. H. Kelley. He illustrated his subject with a laboratory demonstration of the determination of this constant for two types of vacuum tubes used in radio work. He discussed both the dynamic and static method of determining this constant, and clearly showed how any radio amateur can determine this important vacuum tube constant with apparatus already at his disposal.

A tentative program for procedure for coming meetings has been adopted, with the end in view of accomplishing as much as possible in the limited time available. A large number of members of the Armour Radio Association are taking the elective course in "Radio Communication," offered by Professor Wilcox. Whenever any interesting development or experiment of general interest is encountered in the radio laboratory work of the course, it is reproduced at an association, meeting for the benefit of those bers not taking the course. A chance for free discussion is offered so that any part of the experiment which is not as clear as it might be, can be explained by other members familiar with the theory of the experiment

RALPH KENRICK,
Secretary

COLLEGE NOTES

PHI LAMBDA UPSILON.

By authority of the Executive Council, there was installed, in May, 1920, at the Armour Institute of Technology, a chapter of the national honorary fraternity of Phi Lambda Upsilon.

Phi Lambda Upsilon was founded at the University of Illinois as a local honor society, within the chemical department. While the honorary idea was paramount from the first, the original chapter combined with this certain social phases, and included in its organization some of the attributes of the Greek Letter Societies whose aims are primarily social; such as grips, pass words, secret mottos. After a number of years of flourishing existence at Illinois, during which it had achieved a well established position, expansion into a society of national scope was initiated with the establishment of the Beta Chapter at the University of Wisconsin (1906). At Wisconsin the chapter was at first mainly graduate. This first step toward national development was followed by rather rapid extension, chapters being installed successively at Columbia, Michigan, University of Washington, Minnesota, Ohio State, Iowa State, Stanford, University of Denver, California, Pennsylvania State, Purdue, University of Pittsburgh, and Armour.

Accompanying numerical growth were changes in details of organization. Great latitude in organization and government is permitted individual chapters by the national body, the old time "mystery stuff" has been almost abandoned, and the society as a whole stands in the field of chemistry as does the Sigma Xi in the broad field of Science, for the encouragement of high standards of scholarship and for the recognition of those students of chemistry who attain high academic standing through their combined ability and effort.

There are now four classes of membership in Phi Lambda Upsilon, namely: Active, alumni, associate and honorary.

Honorary members, to quote the constitution of the society, "shall be men of national reputation." Quoting further from the same source, "associate members shall be men of recognized ability in their respective branches of chemistry, and connected

with an institution of learning in a capacity other than that of student, either graduate or undergraduate." Active membership consists of graduate and undergraduate students duly elected and may include associate members. The constitution of the society provides that membership be confined to men.

It is hoped and believed that the newly organized chapter will maintain the excellent traditions of the society as a whole and that it may be a factor for good in our chemical department.

The seniors are greatly enjoying a course on the "*Masterpieces of English Literature*" given this semester two hours per week by President Gunsaulus. It is a lecture course, comprising readings, comments, and informal discussions of a number of selections in prose and poetry. The topics considered thus far have been The Book of Job, Homer's Epics, Shakespeare's Hamlet, Richard the III, and The Tempest.

At a recent assembly, the student body and faculty of the Institute had the pleasure of a short talk from Mr. Philip D. Armour, our new trustee. Mr. Armour expressed his gratification at receiving the new position, and stated that in the future he would lend his every aid towards the furthering of the new Institute. As students we wish Mr. Armour all success, and hope that he will visit us often.

The Armour Glee Club at its first meeting of the year, chose Dr. Daniel C. Protheroe, Director of Central Church Choir and composer of many notable selections, as its leader for the year. Dr. Protheroe has held several rehearsals, and states that according to all indications, the Institute should have a better Glee Club than ever before.

Dean Raymond recently attended the ceremonies at the University of Michigan in connection with the installation of the new president, Dr Marion L. Burton.

ADDITIONS TO THE FACULTY.

Arthur Howe Carpenter, M. A., Assistant Professor of Metallurgy, obtained his degree at the University of Ohio at Athens, in 1914. He also spent two years at Northwestern University. Prof. Carpenter's experience in the metallurgical field should make him a valuable man at the Institute. He has been engaged as metallurgist by many of the leading smelting companies in the country and left a position as Research Metallurgist for the American Canadian Smelting Co. to come to the Institute. Prof. Carpenter is a member of the American Institute of Mining and Metallurgical Engineers.

Clinton Everett Stryker, B.S. in E.E., Assistant Professor of Electrical Engineering, graduated from Armour Institute in 1917. Prof. Stryker is a member of the American Institute of Electrical Engineers, and of Eta Kappa Nu, honorary electrical fraternity.

Roe L. Stevens, B.S. in C. E., Assistant Professor of Civil Engineering, received his degree at Armour Institute in 1908. Prof. Stevens is a member of the American Society of Civil Engineers.

John Edward Kelly, M.D., Consulting Physician, graduated from the Medical Department of Northwestern University in 1905. Dr. Kelly is a member of the Chicago Medical Society, of the Illinois State Medical Association, and of the American Medical Association. He has been a practicing physician and surgeon since 1905, and is now Attending Surgeon at the Mercy Hospital.

Harold S. White, B.S. in M.E., Instructor in Automobile Engineering, graduated from Armour Institute in 1917. Mr. White is a member of the Society of Automotive Engineers and of Tau Beta Pi, honorary engineering fraternity. He has done much research work along his line with the government during the war.

Will White Colvert, A.B., A.M., Instructor in Physics, comes from Cumberland University, where he graduated in 1917.

Walter J. Bentley, B.S. in C.E., Instructor in General Chemistry, graduated from Armour Institute in 1920. Mr. Bentley is a member of Phi Lambda Upsilon, honorary chemical fraternity.

Nathan Lesser, B.S. in E.E., Instructor in Elementary Machine Drawing, graduated from the University of California in 1915. Mr. Lesser is a member of the Western Society of Engineers.

Helen R. Curtis, Assistant Librarian, comes to the Institute from the Chicago Public Library, where she was Junior Library Assistant. Miss Curtis is a member of the Chicago Library Club.

ALUMNI NOTES

THE 1920 SPRING ALUMNI MEETING AN DINNER.

The Spring Alumni Meeting for 1920 was held on May 22 at the City Club, and was attended by about one hundred and fifty alumni. Dr. Gunsaulus addressed the meeting and spoke of the new Institute, and he was followed by Dean Raymond, Dean Monin, Mr. R. M. Henderson, and Prof. Wilcox.

At the business meeting, which followed, the following men were elected officers for the year 1920-21:

W. D. Mathews, '99, President.

Herbert Cieck '11, Vice-President.

L. E. Davies '19, Corresponding Secretary.

W. Oberfelder, Corresponding Secretary.

E. A. Freeman, Treasurer.

W. A. Kellner, Master of Ceremonies.

The members of the Board of Managers are Sidney James, F. C. Dierking, and C. A. Knuepfer to 1923; R. M. Henderson, W. J. Baer, and B. S. Carr to 1922; J. C. Penn, R. Harris, and G. N. Siebenaler to 1921.

NEW ADDRESSES.

Clarence Muehlberger, '20, is instructing in chemistry at the Universtiy of Wisconsin, while working for his advanced degree.

Arthur H. Anderson, '02, formerly Assistant Professor of Experimental Engineering at Armour, has recently accepted a position as instructor of steam and gas engineering at the University of Wisconsin.

Stanley Evans, '18, after his recent marriage to Miss Marion Possum of Milwaukee, has settled in Minneapolis as insurance engineer for the Hartford Fire Iusurance Co

Leroy H. Badger, '07, formerly connected with the A. T. & S. F. R. R., is now a mechanical engineer with the DeRemer Blatchford Co., Chicago.

Ronald Baker Clark, '12, is now with the Allied Machinery Co., de France, and is located in Paris.

Ralph M. Crow, '13, has moved from the Office of State Supervising Architect, Chicago, to the Division of Architecture, Capitol Building, Springfield, Ill.

William E. Dady, '19, is architect for the Wisconsin Steel Co., at their Chicago office.

Alan Hetherington, '18, has left the Chicago Edison Co., in favor of a position as electrical draftsman with the New York Edison Co.

Charles E. Eustice, '01, is superintendent of the Galena Mfg. Co., of Galena, Ill.

Frederick Heuchling, '07, is business manager for the Northwestern Trust and Savings Co., Chicago.

Morris Wisner Lee, '99, is vice-president of the Frank D. Chase Co, Inc., Industrial Engineers, of Chicago.

Omar Grant O'Grady, '17, has gone to Natol, Rio Grande de Norte, Brazil, as resident engineer of the Serido Highway.

Robert Perkins, '17, and a Mr. McWayne have gone into partnership as architects. Their headquarters are located at Sioux Falls, South Dakota.

Orson R. Prescott, '04, has left the Ameircan Coal and Products Co., and now is located with American Coke and Chemical Co., Chicago, as engineer.

Tom Hall, '20, after a short period with Morris & Co., packers, has accepted a position as Assistant Editor of "Power Plant Engineering."

Emil Schiffers, '15, is doing general contracting work in San Antonio, Texas.

James L. Shane, '14, has been promoted to the position of superintendent of construction in the engineering department of the Western Electric Co.

BOOK NOTES

The Armour Institute of Technology Library has received the following new books which will be of interest to the various departments:

MECHANICAL DEPARTMENT.

ANDROE, STEPHEN O. *The Petroleum Handbook.*

A condensed book of reference conveying the history, the procuring, the preparation for the market, and the marketing, of natural gas, gasoline, and shale oil.

EASON, ALEC B. *Flow and Measurement of Air and Gases.*

The author investigates the friction of gases and the coefficient of friction in pipes, the question of suitable meters for gas and air and the working of pneumatic tubes. He discusses the foundations upon which graphs and formulae are based.

FAVARY, ETHELBERT. *Motor Vehicle Engineering.*

This work aims to present in a simple, concise way, using the simplest of mathematics, the information needed by the automobile designer and engineer, as well as the draftsman, technical graduate, mechanic, and others interested in motor vehicle engineering.

HAGAR, DORSEY, *Practical Oil Geology.*

A clear practical handbook on the occurrence and geology of oil, based on American methods.

NINDE, W. E. *Design and Construction of Heat Engines.*

This unusually well-arranged book explains the principles and construction of the steam-engine, steam turbine and internal combustion engine. A separate chapter is then devoted to each of the parts.

ELECTRICAL ENGINEERING.

CALIFORNIA RAILROAD COMMISSION. *Inductive Interference Between Electric Power and Communication Circuits.*

This volume, comprising nearly 1200 pages, contains reports on electric induction, electric railway interference, harmonic analysis, general inductive interference, magnetization of iron, and transformer harmonics.

FERGUSON, O. J. *Electric Lighting.*

The author states in his preface, that "Next to the human need for food, shelter, and clothing, comes the need for artificial light. The meeting of this requirement, upon a large scale, becomes an engineering proposition."

JAMES, H. D. *Controllers for Electric Motors.*

The principles of operation and the practical applications of controlling devices are treated in this book. General types, rather than special makes, are described.

PIERCE, G. W. *Electric Oscillations and Electric Waves.*

An advanced mathematical treatise on electric oscillations and electric waves, with special application to radio telegraphy. Their application to optics and telegraphy are also considered.

STEINMETZ, C. P. *Theory and Calculation of Transient Electric Phenomena and Oscillations.*

In view of the serious importance of transient phenomena in huge generators, transmission systems, and high frequency apparatus, this mathematical treatment of the subject will find immediate use among advanced students.

CIVIL ENGINEERING.

BISHOP, CARLEDON T. *Structural Drafting and the Design of Details.*

The author, who was formerly chief draftsman with one of the largest bridge companies, and is now a professor at Yale University, shows a thorough practical and theoretical knowledge of his subject.

CORRUGATED BAR COMPANY, BUFFALO. *Useful Data on Reinforced Buildings for the Designer and Estimator.*

The aim of this book is to give all the data needed by the busy engineer or estimator in meeting the every-day problems in concrete building design.

FINCH, J. K. *Topographic Maps and Sketch Mapping.*

In recent years the development of the automobile and the camping habit has led to a more extensive use of maps. This fact, taken with the demand for instruction in map reading and sketch mapping brought about by the great war, has increased the interest in this subject.

MANUFACTURERS' AIRCRAFT ASSOCIATION. *Aircraft Year Book, 1920.*

An attractive annual containing aeronautical maps, a list of the world's aces, important events in the history of flying and ballooning, aerial mail, technical development of airplanes, and other interesting information.

MEAD, D. W. *Hydrology.*

The work, based on the author's course in the University of Wisconsin, treats of rainfall, floods, geology, ground waters, run-off, stream discharge and other meteorological and geological conditions to be taken into consideration in planning hydraulic engineering undertakings.

CHEMICAL ENGINEERING.

ALDERSON, VICTOR C. *Oil Shale Industry.*

The author of this book was formerly a member of our own faculty and is now president of the Colorado School of Mines. He claims that "the successful retorting of oil from shale and the establishment of the oil shale industry on a permanent and profitable basis is the great problem of this decade."

HOYT, SAMUEL L. *Metallography.*

The general principles are discussed, and there are chapters on the physical and mechanical properties of metals and alloys.

SCHOELLER, W. R. AND POWELL, A. R. *The Analysis of Minerals and Ores of the Rarer Elements.*

The authors of this book on the properties and separation methods of the rarer elements show a very practical acquaintance with their subject.

SEIDELL, ATHERTON. *Solubilities of Inorganic and Organic Compounds.*

This new edition contains chapters describing the sources of data, the methods of calculating them to desired terms, the interpretation of their tabular arrangement, some of the methods used for the accurate determination of solubilities, and the inclusion of the freezing points.

WILLIAMS, R. S. *Principles of Metallography.*

This is a scientific study of the properties and structure of mixed metals. The book treats of the non-ferrous alloys of iron and steel, with emphasis on the practical applications of metallography.

OF GENERAL INTEREST.

Brearly, H. C. *Time Telling Through the Ages.*

An interesting work giving historic facts about the making of timepieces, as well as much information on the science of horology.

Elliott, H. S. R. *Modern Science and Materialism.*

A good discussion, not unduly technical, of the relation between the universe as a whole matter and energy, life and consciousness, vitalism, materialism, and idealism.

Ellwood, Charles A. *An Introduction to Social Psychology.*

It has seemed to the author that a simple statement of the bearings of modern psychological theories upon the problems of social organization and evolution may be useful as a basi for the construction of general sociological theories, and as an introduction to sociology and the social sciences in general.

Henderson, L. J. *The Order of Nature.*

This book on philosophy considers the problem of the physical and chemical origins of diversity among inorganic and organic things, and the adaptability of matter and energy.

Lorentz, H. A. *The Einstein Theory of Relativity; a Concise Statement.*

An effort to explain the Einstein theory in a manner understandable to the educated general reader.

Osler, Sir William. *Old Humanities and the New Science.*

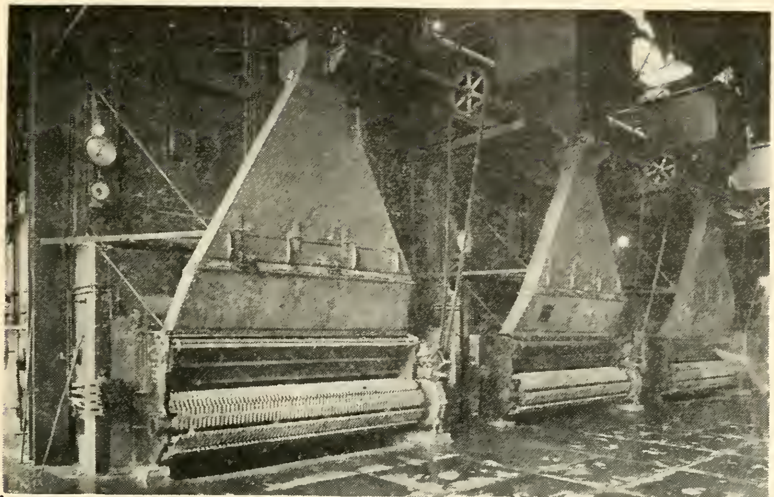
The "Boston Transcript" considers this essay a "rare production, witty, learned, fraught with a high degree of inspiration, full of sympathy for the old humanities."

Tead, Ordway & Metcalf, H. C. *Personnal Administration.*

This book is the first adequate manual for the head of a personnel department as well as for the executive directly in charge of such matters as employment, health and safety, educational development, and joint relations with employees. It gives the principles and the best prevailing practice in the field of administration of human relations in industry. The conclusions reached are based upon the experience of manufacturing plants throughout the country during the past fifteen years.

EDITH H. FORD,
Associate Librarian.

ALPHABETICAL INDEX OF ADVERTISERS.



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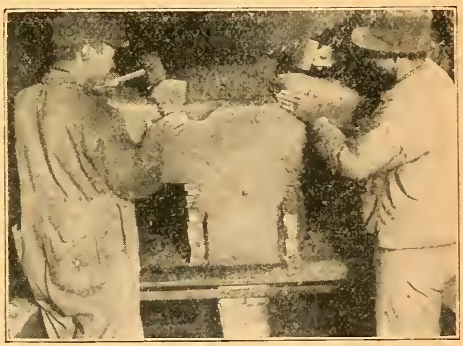

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FLETCHER E. HAYDEN,
Business Manager.

Sworn to and subscribed before me this 7th day of December, 1920.

Chicago, Dec. 7, 1920
(Notary Seal)

GEORGE S. ALLISON,
Notary Public.

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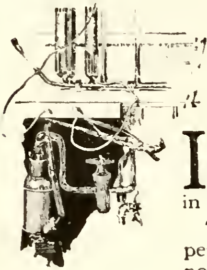

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The Armour Engineer

VOLUME XII. JANUARY, 1921. NO. 2

ENGINEERING AN ESSENTIAL OF ECONOMIC AND MILITARY PREPAREDNESS

By Dr. Frank W. Gunsaulus.
President of the Armour Institute of Technology.

The following article, prepared from an address delivered by the principal speaker before a recent meeting of the Illinois Manufacturers' Association, places an unmistakable charge upon the engineers of the United States in preparedness. Great problems of preparedness for both war and commercial progress lie in the field of engineering. What the speaker did not say, but what engineers will infer, is that they must not only carry out the great engineering problems, but must be leaders in their promotion. A breath of progress such as engineers aspire to pervades this rewritten address.*

The great question before myself, like yourselves, is or ought to be, not what is the attitude of Germany, but what is the attitude of the whole world on the other side of the Atlantic with reference to the supineness, the stupidity, the hesitance, the lack of discipline and force and vigor in our teaching and our practicing the results of science as applied to the solution of practical problems in engineering.

All true education is the education simultaneously of head, heart and hand. Physiologically, you cannot have a good heart without a good hand, and you cannot have a good hand without a good head and a good heart, and you cannot have a good head without a good heart and a good hand. I mean to say that the intellect, as we used to say, and the emotions and the will, the region of dream and duty and integrity, must be contemporane-

*Reprint from the "Professional Engineer."

ously educated and that means the doing of things that we feel an obligation to in the form of duty and that we see in the dreamland of imagination. That gets the blood circulation through the whole human body; that gets the gray matter of the brain into the ends of one's fingers.

We must remember that the weakness of our American education has been in the fact that we have sent the head to school and the heart to church, and the American hand has been about as worthless and useless and uneducated a thing as there ever was in the universe. My plea tonight for handicraft is a plea for patriotism. It is a plea for country. It is a defense, not against Germany, but against flaccid, brainless, horn-blowing Americanism.

The recent war was a war of engineers. Every force of modern engineering ever discovered was taken and used by a nation wise enough to have trained the hand with the head. Germany took our barbed wire fence for war, took our armor plate for war, took our machine guns for war, took our submarine for war, and when the Zeppelin failed, took our aeroplane for war. She was not guilty of petit larceny. It was grand larceny. It was the larceny of a great, big brainy people with strong, cultivated hands, trained hands.

Now we are face to face with the fact that Germany, having outgeneraled us in what we call statesmanship, or in what we may call international politics, and having had the world so long where she could say, "If you don't let me behave as I want to, I won't pay my debts," has the opportunity to so get herself together, with the interests of exchange not altogether against her, and with prodigious industry, that the other day when the American Locomotive Works and the Baldwin Locomotive presented their bids for engines for Java and Sumatra, the vice-president of the Baldwin Locomotive Works told me that they woke up to the fact that even though they had done their best, Germany by three or four thousand dollars on each engine won the day and will supply Holland with her locomotives for Java.

Now I am not inveighing against Germany, but I do not respect the kind of Americanism that forgets how nearly we were strangled to death because we had not educated the American hand.

What are the immediate problems at home, then, that a person

in my position ought, noblese oblige, to speak to you about to-night? The problems of engineering that must be solved if we are even to maintain our place, and much more soon and much more vividly must they be solved for all the people if we are to advance.

One hundred thousand American professional engineers have the glory of their profession to-day because we have learned in America to feed nations. Think of it! Herbert Hoover, the most able man in my judgment that this war has developed, an engineer, has taught the world the ability of America, under proper management and discipline to keep a world from starving to death. Do you suppose there are not greater difficulties in the future? Because we have apparently won this war, must we close our brain to the fact that we can lose the war because our brains are inside of a bushel?

I tell you, men and women, a war is won in the mind of a people and it is lost in the mind of a people. There is no power that we know of in the history of human thought that can forecast so certainly the failure of what is merely a physical event, no power of which we are so certain as that self-conceit which is having its orgy of discourtesy and contempt to-day; that self-conceit that poisons the mind and infests the imagination and ruins the character of a great people.

In the first place, let us take some of the problems of civil engineering. The great man of Germany to-day is Hugo Stinnes. Mr. Hugo Stinnes is the man who first of all said, "This great factor of coal is fundamental. The next fact is the way to get coal to the Krupp factory." So all of the little rivers of Germany were used and inland waterways were constructed by civil engineers, and when finally the Krupps broke down, and Bertha's husband was unable to run things successfully, Hugo, the man who built great works, made his appeal to oil, fuel oil. Then he began to open huge pits of lignite, and he began to break down mountains of shale, and he began to extract oils, oils, oils, and so completely did his inland waterworks succeed in carrying to and fro the burdens that needed to be carried to and fro that he concluded to organize the banks of Germany that had helped him to do business.

By and by he bought the Atlanta Hotel in Berlin, with giving up some of the twenty-six newspapers that he owned in Germany.

Then he bought another large hotel in Berlin and he became the owner in the face of twelve million men of the very thing they had dreamed about, a socialized state.

Now this is not a man of yesterday but he is a man of to-day. He is the man in Germany to whom the Germany of the Hohenzollern idea looks with hope. Here we are, for example, in the United States with a great struggle for coal. Any man who knows anything concerning the subject at all knows that we are behind our own Americans who had the vision and inventiveness of mind long ago to perceive that in this great country there must be such use made of waterways that in any crisis fuel and food could be given to the people.

You can see in the drawing made by Robert W. Fulton, civil engineer, published in 1796, almost everything that this great German mind of patriotism and imagination has put into the form of active machinery, and the Germany of to-day is a Germany in which other things being equal such an outrageous program as was proposed by those Americans interested in the higher price of coal would be simply a laughing matter; nobody in Germany would take it seriously.

A representative man of South America came to Armour Institute the other day and said, "I am up here with a commission to find out why it is that this great Central West of yours cannot send to South America its products in such a way and at such a time that it is worth while for us to buy it up here?" He sees that at the present time all of the shipments from the Central West have to be shipped by way of New York. He has brains enough to see that between Chicago, the capital of this great field of grain, silver, steel, iron, of everything, and New Orleans there is the simplest problem of engineering which any great nation has had put before its imagination or its learning.

Why there are sixty-eight miles of declivity, for example, that would furnish by accurate computation two million dollars worth of power if it were properly used by engineering processes in the course of a single week. We have been losing, in spite of all that Isham Randolph has done—a name of one of the greatest engineers and one of the greatest friends of the Middle West and Chicago and this nation,—we have been losing millions and millions of money. Not only have we been losing that but we have been losing international relationships and a vast business.

Suppose in the course of this war, we could have sent food down our rivers instead of waiting for railways? Suppose we had been able to send even to the Gulf of Mexico, and suppose, further and more interestingly, we could have been able to send food to the Atlantic seaboard in large measure,—do you suppose that there would have been any such suffering?

If I were to talk here until morning, I should not exhaust the subject of what must be done in civil engineering with respect to our railways, but I shall not enter upon that theme.

If I were to go into the intricacies and refinements and theories of chemical engineering, I should be able to tell you how all the vast corn fields in the West have been under experimentation and discussion with regard to the making of paper. I should tell you how lignite has come to be as important a thing in all the traffic of the world and the progress of the world's future as any single element that has been discovered in 150 years. To-day there come to such institutions as ours great problems from the manufacturers of illuminating gas, and they know as well as we that the engineer is the man who must think these things out.

Engineering education is not like any other kind of education that I know of, or ever experienced. When I went to school we studied such subjects as came under the purview and jurisdiction of my father and mother. I could go home and complain, and there were mighty few propositions in all the realm of my grammar that could not be arranged for at home to suit the taste of the little son. When you get into an engineering school, the shortest distance between two points is a straight line. Mama cannot help it, the doctor cannot help it, papa's money cannot help it. It is not so because the parson said so. Priests have no place. You could not organize a jurisdiction ecclesiastical in geometry and have a lot of priests stand outside and say, "Believe this or go to hell."

And the education of the engineer in America means, with one hundred thousand of them at work now, straight-forward thinking men,—and the harder the stuff in which he works, the surer the groove of the thinking.

A boy takes an instrument at the Armour Institute of Technology fitted to make a screw thread one-eighty thousandth of an inch fine. If it is one-eighty-five thousandth of an inch fine, that tool will tell on that boy more certainly that will the tool

which makes a thread only one-eighty thousandth of an inch fine. The higher up you go, the nearer you come to radium and the X-ray.

Just the touch of that screw on a telescope and you are away over there some place, and it will take you a good many days and months and years to find out where you are, for you must calculate it all from here.

I tell you a man that has preached, or a lawyer that has argued cases before the court, or any kind of a rhetorical brother, gets the rhetoric all knocked out of him when he comes down here and finds that he has to talk in lines one one-hundredth thousandth of an inch fine.

Now, how can we neglect the kind of education that makes a man think in straight lines; and makes him know that truth is set down because it is true, and that it is not true because it is set down; that it is better for a man to tell the truth, but that the truth is utterly independent of the man?

Well, I will tell you what we did for help in getting finer screw threads. We went to John Brashear of Pittsburgh and told him of our difficulty. He knew of a worm in Portugal which spun so fine a thread that we could not compare for fineness the filament of a spider's thread. The spider's thread was entirely too coarse, too much like a rope. We got this worm and had this worm go to work for us, and he spun that thread so fine that we made a calculation. Now, that thread is so fine,—well, let us make the calculation right here. You remember when John Field said to Robert Louis Stevenson, "Where shall I find you?" They were standing in San Francisco looking toward the west. Robert Louis Stevenson said, "At the first house on the left," and he pointed across the Pacific. The first house on the left, the first big star, is Alphaeus Santori. Now let us calculate a little.

If I were to take this filament and peddle it out at the end of my wagon, starting from Chicago, going to San Francisco, and from San Francisco to Honolulu, and from Honolulu down around to Hong Kong, China, and into Persia to Constantinople, and from Constantinople to Rotterdam, and from Rotterdam to New York, and New York to Chicago, I would use just eleven and two-thirds ounces, but if I had a wagon and started out to go to that star, which is indespensable in astro-physical calculations, and would peddle this fine filament out, it would require

three hundred thousand tons! Now, that is the kind of a universe in which your engineer lives, and it is right in that sort of universe that the battle is to be won.

It will be of interest to Armour students and graduates to know that the Institute is in possession of the original of Herbert Hoover's great work, the translation from the original Latin of "De Re Metallica," by Georgius Agricola. This work covers metallurgical processes, geology, mineralogy, and mineral law from the earliest times to the 16th century.

OBTAINING LIQUID PRODUCTS FROM COAL

In obtaining liquid products from coal by hydrogenation under pressure, coal is used which contains not more than 85 per cent of carbon referred to dry substance free from ash. In an example, 5 kilos of coal having a carbon content of 74.48 per cent on the above basis was mixed with 10 kilos tar oil and heated for six hours under a pressure of 100 atmospheres of hydrogen. 87 per cent of the coal was converted into liquid products as against 11 per cent of a coal with a carbon content of 92.1 per cent similarly treated. (Chem. & Met. Eng., 12-22-19).

ECONOMY OIL BURNING FURNACES

By LeRoy H. Badger, Mechanical Engineer.
De Remer Blatchford Company.

Oil burning furnaces are varied in design and in their method of combustion but the furnaces herein described are designed to give the most heat and the best distribution of heat possible for the amount of fuel consumed.

In the installation of oil burning furnace equipment, a very important factor is a knowledge of the contents of the fuel used. The ordinary oil used, commonly called fuel oil or crude oil, has an analysis approximately as follows:

Carbon ....85 per cent
Hydrogen ....11 per cent
Oxygen ....2.5 per cent
Nitrogen ....0.6 per cent
Sulphur ....0.9 per cent
Gravity 26 to 28 Baume
Weight per gallon 7.3 pounds
Vaporizing point 130 deg. fahr.
Calorific value varies from 18,000 B.T.U. to 19,300 B.T.U. per pound.

As a comparison with other fuel it might be well to state that coal has a calorific value which varies for different grades, but for ordinary grades runs about 12,000 B.T.U. per pound. Natural gas gives 800 to 1000 B.T.U. per cu. ft. and coal gas 590 to 650 B.T.U. per cu. ft.

Of the advantages of oil over other fuel the following items are the most important:

(a) Reduction of waste is made, for in handling oil there is very little loss, and in handling large quantities of solid or gaseous fuel, this is a very large and important factor.

(b) It is much cheaper to handle oil, there being less weight to haul and much less labor required to load and unload it from the cars.

(c) The storage space required is very much less and in a large plant this amounts to a great deal.

(d) One of the most important factors is the elimination of ash and smoke. In some states, supervision requires that all smoke be eliminated from shops, and this is accomplished very easily by the use of oil without the necessity of having smoke-stacks to carry off the smoke.

(e) Correct and even distribution of heat is obtained and the required temperature can be maintained very readily because the supply of fuel is so easily regulated.

(f) Oil ignites instantaneously and a furnace can be brought up to the required temperature much quicker.

In obtaining proper combustion, the atomization of the oil is very important. To obtain this properly, the method used is to force the oil through a small opening under a pressure of at least 15 pounds per square inch (see center section of burner in Fig. 1) and to force a stream of air through a tube surrounding the first tube under a like pressure. The end of the air tube is cup shaped to force the air over and through the stream of oil as it comes out. This contact of the oil and air causes atomization, but this is further accomplished by the aid of an automatic preheating and straining device through which the oil passes. This is heated by means of a pipe extending through the wall of the furnace. The end is stopped just about 2 inches above the top of the preheater. There is a gate placed in this pipe to prevent an excess of heat coming out, and with this the temperature of the oil is regulated so that by the time it reaches the nozzle of the burner, it is nearly at the point of atomization. This arrangement of preheater and pipe may readily be seen on any of the furnaces shown in the cuts. All dirt and water is separated from the oil by this strainer, thus allowing the use of very poor grades of oil which could not otherwise be used, and at the same time getting the required value from the combustion. Any dirt or water in the oil will cause what is commonly called "spitting" of the burner.

The amount of blast is also very important. Oil, for proper combustion, requires about 1650 cubic feet of free air per gallon. Therefore it is very necessary to control the blast and at all times have just the proper amount for the oil being consumed. This is regulated by means of a gate and an experienced man can readily tell when the amount is correct, by the appearance of the flame.

By the use of the combustion chamber shown in Fig. 1. much is accomplished toward the complete combustion of the oil. The blast as will be seen, passes up through a tee shaped pipe, dividing and going up passageways on both sides of the chamber. These passageways are at all times quite hot and the blast is therefore preheated before it reaches the point of contact with the oil to produce combustion. Because of this preheating of both oil

and air before they are mixed for combustion, a great saving in the amount of fuel required is obtained.

For the proper operation of this combustion chamber the following essentials are required: 8 ounces or more of fan blast and 15 pounds or more pressure per square inch on the oil and air lines.

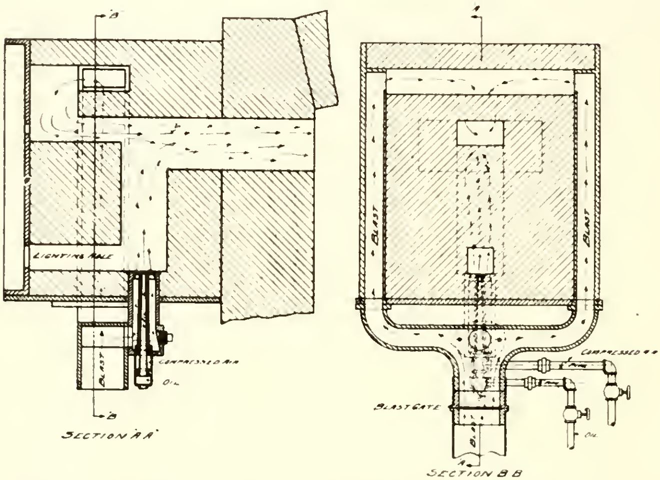


Fig. 1. Details of burner and combustion chamber. The path of the blast oil and compressed air, by means of which perfect combustion is obtained, can be noted.

The recommended oil line system is as follows: a large storage tank of the required capacity is directly connected to an oil pump. From the pump the oil line is taken through or around the shop building and returned to the storage tank. A pressure regulating valve is placed near the pump on this line, and is set at approximately 20 pounds per square inch. Another of these valves is placed just before the return line enters the tanks. This valve should be set at approximately 15 pounds per square inch. Between these two valves all branch lines to the furnaces are taken off. By the use of this method the pressure is maintained evenly at all times, which in turn gives better results at the furnaces, for a varying pressure will give a varied amount of heat.

The refractory material used in the lining of the furnaces and combustion chambers is another important factor. As the temperature in furnaces varies from about 1200° to 3000° Fahr., the length of service varies in the different types of furnaces. However it is the best plan to use a very high grade of fire brick in all types. This saves money in the long run, for it costs as much to put in the cheap grade as it does the best grade.

Fire brick should be laid in a good grade of fire clay and care should be used to see that the clay is not too thick. The usual method is to dip the brick in the clay. Contrary to the methods used in ordinary building brick, there should not be a thick layer of clay between the layers of brick. When brick is laid in the above manner, on applying the heat, the brick and clay fuse together forming a solid wall, with no open joints.

At all times in constructing a furnace the lining should be of sufficient thickness to withstand the temperature required without permitting excessive heat to reach the outer casing.

A very good grade of fire brick as used in the furnaces here described has an analysis about as follows:

Silica	57.77%
Alumina	37.74%
Ferric Oxide	2.55%
Lime	0.60%
Magnesia	1.18%
Soda & Potash	1.18%
Specific gravity	2.60

The softening temperature should be for cone 33. Cone 31 is that required for the furnaces.

The crushing strength should be about 1000 pounds per square inch with brick on end.

Spalling should not be more than 2% or 3%
Penetration should not exceed 0.13 inch.

Allowed expansion	1%
Allowed contraction	1.5%
Porosity approximately	18%
Water absorption	9%

The above analysis gives a high grade brick which will withstand all ordinary temperatures up to 3200° Fahr. and will outlive the lower grades of brick by more than two to one.

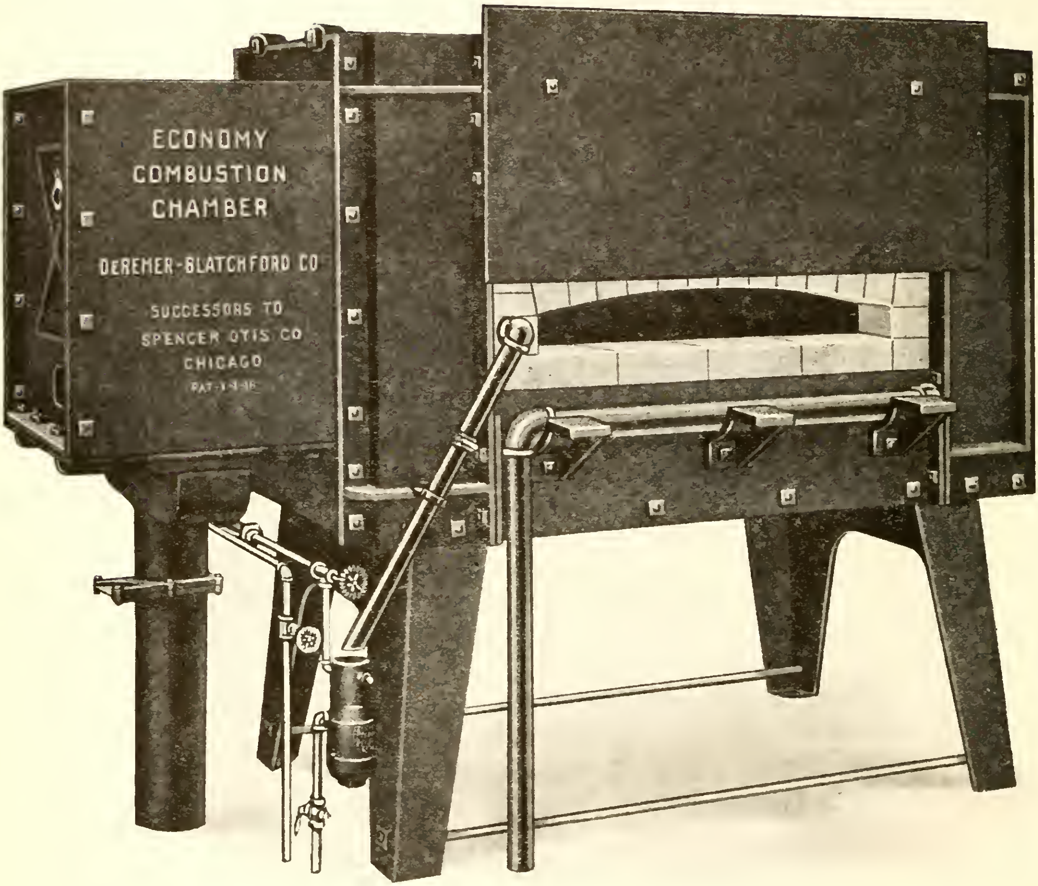


Fig. 2. Standard type forging furnace. Details of construction shown in Fig. 3. Note heat-deflecting pipes, protection shield and arrangement of the oil preheating and straining device.

An attempt will be made to give a brief and comprehensive description of the various types of furnaces most commonly used.

Forging furnaces are the most common type used and will be treated a little more fully than the other types. Fig. 2 shows a standard type of such a furnace. These are used for all kinds of small forgings, and even for some of the small hammer work. The temperature required for this class of work is from 2600° to 3000° Fahr. Necessarily the lining must be of a quality and thickness to take care of this high temperature. The worker is protected from the heat from the working opening by means of an asbestos shield and blow pipe. This pipe deflects the heat up behind the shield. Thus he is enabled at all times to watch the work and not overheat it.

The general arrangement of this furnace is shown in Fig. 3. This is only one size but this class of furnace is manufactured in any size desired for small hand work.

The following description of the action of the heat on the brick work will apply to any of the furnaces.

The temperature is very often brought from a dull red heat to full heat in a very short period of time, and this causes the refactory lining to undergo such a swift change that spalling soon will result. This is possibly more pronounced in the arch than elsewhere for the loose pieces drop to the floor. However with an even distribution of heat there is very little difference in the life of the brick in the sides and arch.

The side walls are subjected to a coating of slag consisting chiefly of iron and its oxides. The result of this scale is to exert a cutting action upon the lining, and if it does not eat away the refractory material it penetrates it and thereby hastens spalling.

Nearly all of the furnaces of this type are made of the leg type as shown. The casing is made of cast iron, cast in sections and bolted together and further strengthened by the use of tie rods. The purpose of making it in sections is to provide more latitude for the expansion which is bound to result when it is heated up.

Annealing furnaces are, as the name implies, used for different kinds of annealing, and the temperature maintained averages about 1400° Fahr. The construction of the brick work varies greatly in this type, some having muffle arches to prevent the impinging of the flame on the work and to more evenly distribute

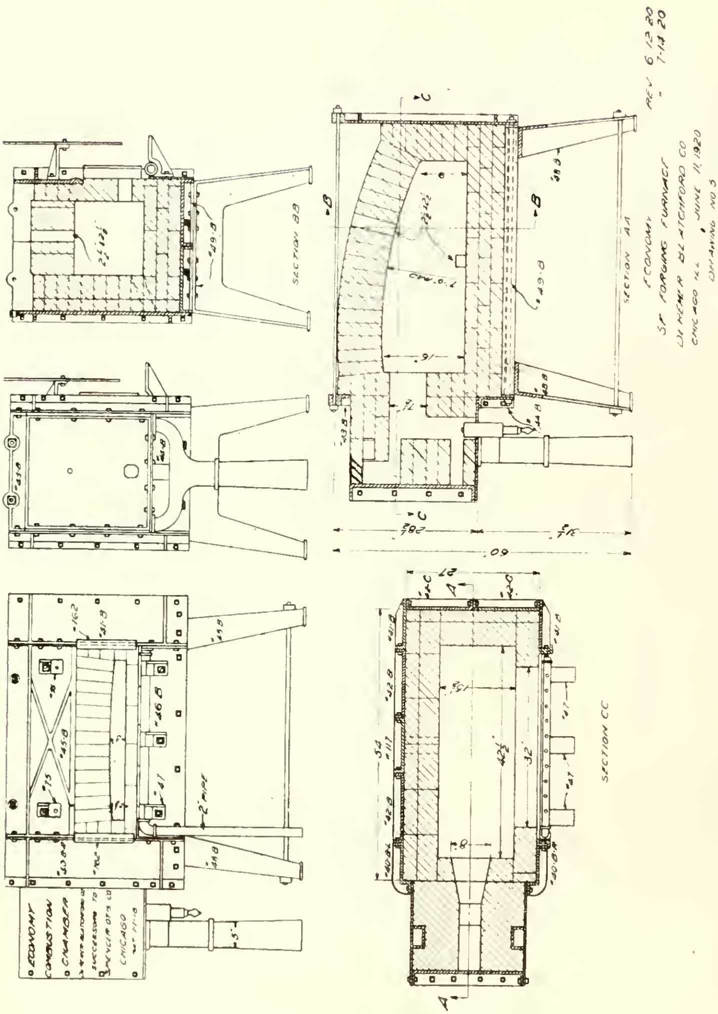


Fig. 3. Details of a standard type forging furnace for hand work and small hammer work.

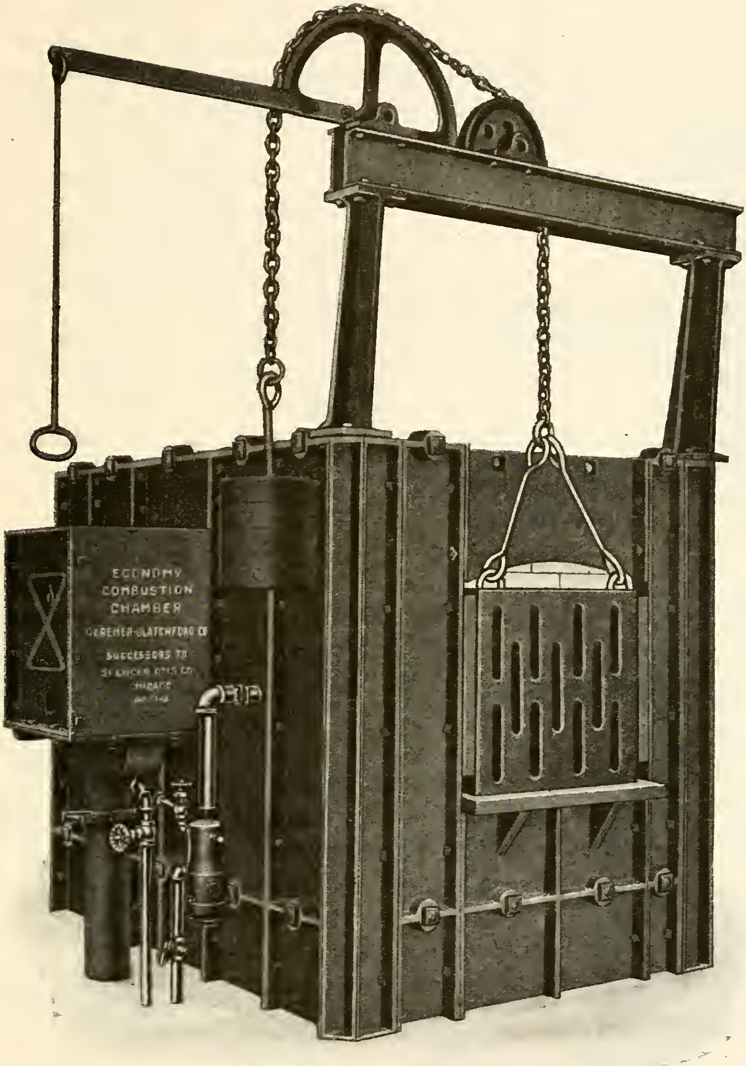


Fig. 4. Small size hammer furnace. Note preheating arrangement. Details of construction of this type shown in Fig. 5.

the heat. The best type for work of this nature is what is called the car bottom furnace. This is so constructed that the work for annealing is loaded on a car which is run directly into the

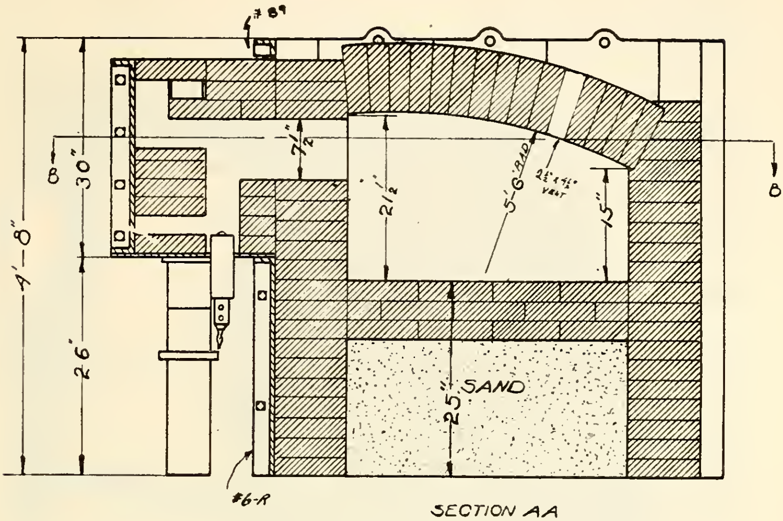
furnace. In this way there is no loss of time in charging the furnace and no consequent loss of heat. The side walls are so constructed that there is a comparatively tight joint between the wall and the top of the car. The floor of the car is covered with fire brick.

Bulldozer furnaces are used for all classes of work done on bulldozers and therefore vary considerably in size. The temperature required for this class of work ranges from 1700° to 1800° Fahr. The casing is constructed of heavy castings, well ribbed and securely held together with bolts and tie rods. The burners are usually placed on one side and the arch slopes to the other side, to give the heat a better circulation. The sizes run from 3′-0″ x 5′-0″ single furnace to 6′-0″ x 11′-0″ double furnaces. The benefit of the double furnace is that the bulldozer can be kept busy by working first from one side and then the other with no delay due to charging.

Flue welding furnaces are small and of the leg type. They are so constructed that three flues may be heated at once or one superheater flue may be heated. The heat necessarily must be very intense and consecrated. The temperature required is from 2600° to 3000° Fahr.

Hammer furnaces are a very common kind and are used for all large forgings, that cannot be forged by hand. As they usually are placed near a hammer it is very essential that they be constructed to withstand the continual jar. The casing is made similar to that of the other furnaces except that in most cases an additional brace or buckstay is added to hold them rigid. A small one of this type is shown in Fig. 4. This is 3′-0″ x 5′-0″ inside dimensions as shown on Fig. 5. As will also be noted only one combustion chamber is used for this size, and the brick work is so constructed that an even distribution of heat is obtained. These are built in any size depending upon the nature of the work to be done.

Muffled tool furnaces are specially designed for the tempering of tools and like work. The best design has two working chambers, one for high temperatures, and the other for low temperatures for tempering. The working of the tool is done in the open chamber. The two different temperatures are obtained by forming a muffle which is not open to the direct flame and derives its heat through the walls of the muffle. The outer part



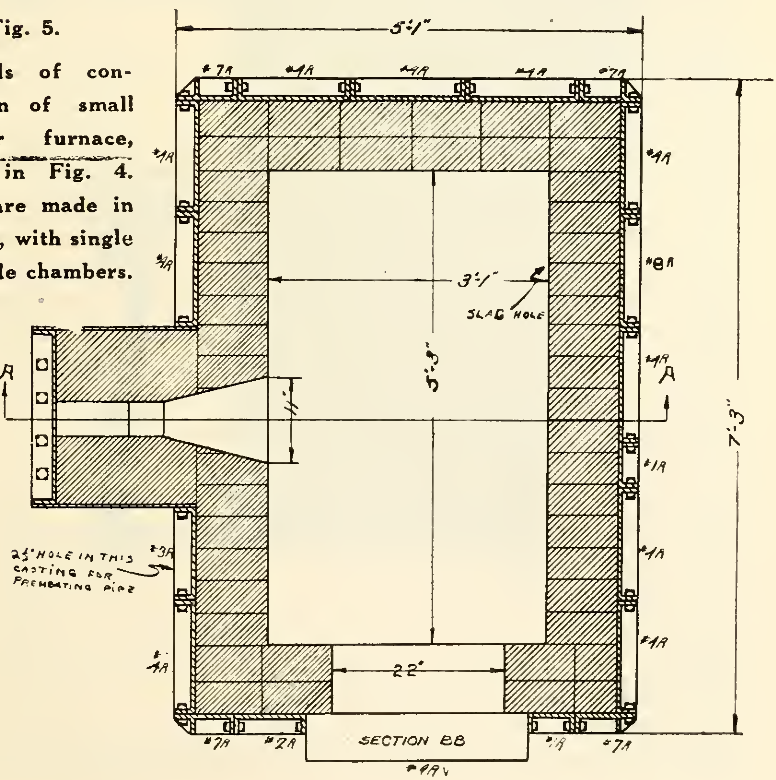


Fig. 5.

Details of construction of small hammer furnace, shown in Fig. 4. These are made in all sizes, with single or double chambers.

has the flame directly into it. The floor has a checker work of brick underneath so that the flame circulates completely around the muffle. The work in this type of furnace is usually governed by a pyrometer so that it is very easy to maintain the correct temperature. The temperature required is from 1400° to 1500° Fahr. in the muffled chamber, and from 1700° to 1800° Fahr. in the open chamber. These are constructed in either the small leg or the full length type.

Plate furnaces are varied in size according to the size of the plates to be heated. They are constructed with a low arch and a low door opening and are so arranged that the entire plate is heated uniformly. To accomplish this in the case of circular plates it is necessary to have a hollow bottom with vents in the floor that allow the heat to come up against the bottom of the plate in the center. A sample of this type is shown in Fig. 6.

Rivet machine furnaces are used for heating the rods before they are fed to the rivet machines. The rods are fed directly from the furnace and are thus kept hot until the last reaches the machine. They are long and narrow, usually about 25′-0″ long and about 23″ wide. All burners are placed on the same side. The arch slopes down quite sharply to the other side. This together with the hollow bottom insures an even distribution of the heat at all times. The temperature required is from 1700° to 1800° Fahr.

Spring and casehardening furnaces are used for working spring steel and for case hardening. The temperature for spring work is about 1600° Fahr. although this varies with the class of spring steel used. The flashing of the temper is accomplished in a muffle chamber away from the flame. The furnaces are so arranged that two spring fitters may work at the same one.

In all of the furnaces above described and all others it is necessary to consider the space to be heated in determining the number of combustion chambers required. One combustion chamber will properly heat a space of from 30 to 40 cubic feet. The amount of oil consumed will vary according to the temperature required but will run from three gallons per hour on the small and low temperature furnaces, to eight gallons per hour on the large and high temperature furnaces.

The control of the oil supply is obtained with a needle valve placed between the preheater and strainer, and the burner. The

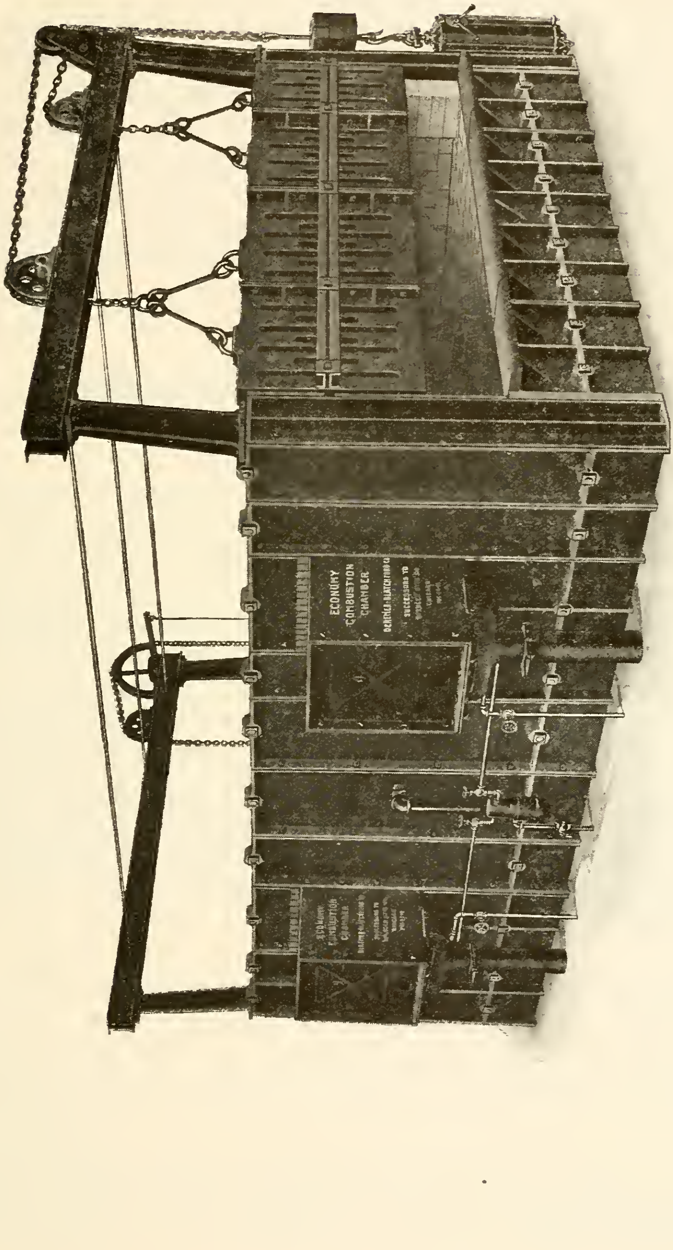


Fig. 6. Typical furnace for plate work. Made in any desired size.

control is so exact that with all conditions as they should be, the burners can be set to give the desired heat and will require no adjusting to maintain that temperature.

The few different types described are for the most general kinds of work, but give a fairly good idea of the field covered. In all cases a furnace should be designed for the particular work it will be called upon to do, for in this way only are the two greatest essentials derived; namely efficiency and economy.

An attempt has been made to make the furnace proposition as clear as possible, without going into too many details and without centralizing on any particular kind, as the field is very large and varying.

THE FEDERATED AMERICAN ENGINEERING SOCIETIES

One of the most encouraging of recent developments in the engineering world, is the organization of the Federated American Engineering Societies. This organization, embracing as it does the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Institute of Mining and Metallurgical Engineers, stands in a position where it can direct all the Societies toward a common goal. It can eliminate much of the friction between the various branches that has heretofore existed, and can establish in its stead, a unity of effort that will help all. Herbert Hoover, the president of the Federated Societies, is a man of broad understanding, and is fully capable of the task before him. We appreciate the difficulties confronting such an organization in its early years, and wish it much success.

THE APPLICATION OF AUTOMATIC SUBSTATIONS TO INTERURBAN LINES

By Charles H. Jones '09.

The cost of power on the average interurban property is one of the large items of operating expense. The unit is usually very high, due to the lower load factor and high operating charge. Substations are usually 300 or 500 K. W. units and the operating charges on this size of stations are as heavy as those on large stations. It is usually the case to combine this operating work with some other, such as that of ticket or freight agent. This is not very satisfactory as the kinds of work are entirely different. A man does not become proficient in operation as the majority of his work is that of an agent. and substation operation is only a side-line. This desire to combine jobs very often is one of the fundamental ideas considered in laying out the substations and the result is that an ideal power system is sacrificed to operating expense. In the long run an inefficient power system results.

Often several machines are placed in a station when it would be to the general advantage of the system to spread them out, but the high cost of operation prevents such a layout. The automatic substation has done a great deal to correct this error as it has made possible the additions of substations without corresponding increase in operating expenses. This has resulted in a radical change in power conversion and distribution engineering, for it has shifted the investment from distribution copper to automatic substation control equipment in the substations. These changes result in reduced operating expenses, reduced line losses and reduced idle running time of converters. The latter two are very important and in many cases will show a greater saving than that made in operating labor.

Another factor of considerable importance, is the speed of operation in case of emergency and the positiveness of such operation. This is not the case with hand operation, as under adverse conditions the rather inexperienced operator in stations of this type does not function properly or as quickly as automatic equipment.

The introduction of automatic substations came about at a time when electric railway properties were doing practically no extension work. On account of serious financial difficulties

and inability to raise money, very few installations were made, although a saving could have been made in operating expense due to their installation. The result has been that practically all installations which have been made were due to either an extension of the system or a rehabilitation of the power system.

The Chicago, North Shore & Milwaukee Railroad, a high speed heavy service interurban line between Chicago and Milwaukee, was one of the pioneers in the installation on interurban systems. In fact, it is practically the first extensive installation for heavy service. The passenger equipment consists of 45-47 ton steel cars equipped with four 140 h. p. motors each; 15-40 ton steel trailer cars; 40-38 ton wooden interurban cars with four 75 h. p. motors per car. There are also 22 express cars with two motor equipments, two 40 ton and two 50 ton locomotives and 150 freight cars, together with the usual complement of line cars, work cars, plows, sweepers, etc.

An hourly high speed limited service is given between Chicago and Milwaukee, a distance of 86 miles, on week days and half-hourly service on Saturday afternoons and Sundays. The running time is two hours and thirty-five minutes on regular limited trains and two no-stop trains are operated in each direction daily making the run in two hours and ten minutes. The schedule speed is 34.5 miles per hour but about 38 miles of this is through cities and towns which require a reduced speed, so that for the balance of the run it is necessary to maintain a speed of over sixty miles per hour. For this service, the equipment is operated in trains of from two to five cars. A half-hourly express service is also maintained between Chicago and Waukegan, and a half-hourly local service between Evanston and Waukegan.

In addition to the above service an extensive merchandise dispatch service is handled between Chicago and Milwaukee. Over a part of the system considerable carload freight is handled which consists principally of sand, gravel, stone, and coal.

From the above tabulation of service rendered it is evident that considerable responsibility is placed upon the power system.

In 1906 the power system was only sufficient to handle single car service using a 38 ton car. With the purchase of additional car equipment it became necessary to increase the power facilities. At this time a very careful study was made of the various

methods available, which were the raising of the line voltage, the addition of feeder copper, or the increasing of the number of substations. On account of the large amount of old motor equipment which would not stand an increase in operating voltage, the changes in control equipment necessary for operation on two line voltages, and the probable municipal objection to a 1200 volt system in cities, it was decided that the first method was out of the question. Calculations made on the feeder system, showed that the amount of copper required was so great as to make the cost prohibitive, and in addition the line loss would be very great. Therefore, it was decided to increase the number of substations. The spacing at that time was approximately 13 miles on the north end of the line, which is in high speed territory, and the one where most low voltage trouble was encountered. A careful investigation was made of existing automatic substations at that time and it was decided to make the new stations automatic. These are located approximately half-way between the hand stations. Two of these were installed in 1917 and one in 1918. The rotary equipments were obtained from other parts of the line where larger sized machines were installed in the manual stations. The automatic equipment was purchased new and installed in buildings erected for this particular purpose. All of these installations were made with 500 K. W. 25 cycle equipment.

On account of the pressure of war business at the Great Lakes Naval Training Station it became necessary to make a manually operated temporary installation of a new 1000 K. W. rotary. This equipment was intended as automatic and the building was erected accordingly. The automatic equipment was added in the winter of 1918 and 1919. Since that time automatic equipment has been added to one of two 300 K. W. machines in the Libertyville manually operated substation.

A sixth station is now in the course of installation to replace a portable substation at Ravinia Park. This is to be a 1000 K. W. 60 cycle installation, which is the first station of this frequency to be installed on the line.

In the installation of this type of station it is possible to effect considerable economy in building construction, due to the fact that the conveniences usually provided for operators, such

as plumbing, heating, etc., can be eliminated. Single unit station buildings are all that are needed, as the theory of the system demands many stations and short feeding areas. The substation buildings used on the North Shore Line are one story in height without basements, and have shallow machine pits, the floors of which are raised about two feet above the surrounding ground level to prevent the accumulation of water. The foundations are of concrete and extend to a point 6 inches above the floor level. The walls from this point up are of brick. Pressed brick is used outside and common brick inside. The roof, which is of 3 in. reinforced concrete, is supported by steel beams, one steel column being located approximately in the center of the building. The floor is of 6 in. concrete laid on a cinder bed. Light is admitted through wire glass windows set in steel frames just below the roof on three sides. Ventilation is provided by louvers on all sides just above the floor, with Burt Ventilators in the roof. High tension line entrance is made through the roof with 45000 volt roof bushings. The building is of sufficient size to accommodate equipments up to 2000 K.W. capacity.

The automatic equipment is comparatively simple in its operation and its performance corresponds with that which takes place in the automatic accelerating equipment on multiple unit trains. The conditions under which it performs are a great deal more favorable in the substation than on a car. The number of operations is bound to be a great deal smaller than on car equipment. The latter have stood the test of time and therefore there is no reason why the substation equipment will not stand up equally as well. The various protective devices used are no different than those which have been used in manually operated substations for years, and their performance is known. The various contactors, etc., used, have had long tryouts in industrial work, and have given satisfactory results.

When high tension switching problems are involved in the station under consideration they require careful analysis, as very often it will be possible to handle them at a point, where otherwise men would be required for the twenty-four period.

The results of automatic operation have been very gratifying and from our experience I have come to the conclusion that in the future the automatic substation will play a very important part in railway electrification problems. It has put a new feature

into the direct current system on account of its having made possible greater limits for 600 volt application due to a reduction in the cost of feeder installation and in the line losses. This is a great advantage as the lower line voltage lessens the difficulties encountered in the maintenance of both car and overhead equipment.

WIRELESS TELEPHONY AS A POLICE AID

The use of the wireless telephone as an aid in the prevention of crime is being tested by the Police Department of St. Louis. A sending outfit with a range of forty miles has been installed at the police headquarters and three automobiles have been equipped with receiving apparatus. By this means it is possible to change the orders of a squad while it is at work. One man in each automobile has the receiver strapped to his head at all times. If, for instance, a squad were sent out on a false clew and correct information reached headquarters after the men had left, it would be possible to stop the wild-goose chase and give the squad the proper orders.—*Electrical World*, Jan. 1, 1921.

FUEL AND AIR MIXING DEVICES FOR INTERNAL COMBUSTION ENGINES.

By Daniel Roesch, '04.

The correct proportioning of fuel to air supply, and the homogeneous blending of the mixture, are of vital importance to the satisfactory operation of internal combustion engines.

THEORETICAL PROPORTIONING.

The theoretical air requirements may be computed for the fuels most commonly used in combustion engines as follows:

For Natural Gas: (By Volume).

Principal Constituent, Methane (CH_4)

$$CH_4 + 2O_2 = CO_2 + 2H_2O$$

Then for each cu. ft. of Methane 2 cu. ft. of O_2 are required.

Since air by volume is 21% O_2 and 79% N_2

$$\frac{2}{21} = 9.53 \text{ cu. ft. air required per cu. ft. of natural gas.}$$

For Natural Gas (By Weight)

$$CH_4 + 2O_2 = CO_2 + 2H_2O.$$

Molecular weight of $CH_4 = 12 + 4 = 16$.
Molecular weight of $2O_2 = 2 \times 32 = 64$.
Molecular weight of $CO_2 = 12 + 32 = 44$.
Molecular weight of $2H_2O = 2\ (2 + 16) = 36$.

or

16 lb. CH_4 unites with 64 lb. O_2 to form 44 lb. CO_2 and 36 lb. H_2O.

Therefore, for each lb. of CH_4 burned $\frac{64}{16}$ or 4 lb. of O_2 must be furnished.

Since air is 23% O_2 and 77% N_2 by weight, the air requirement is

$$\frac{4}{0.23} \text{ or } 17.32 \text{ lb. per air per lb. of natural gas.}$$

The computation of Air Requirements for Gasoline is made complex because gasoline is a mixture of various hydrocarbons.

When it is desired to compute the air requirements in a similar manner as that given for natural gas, it is necessary to know the nature and amount of each constituent. The individual air requirement of each constituent is then computed in accordance with the amount of the same present in a unit volume or weight. The sum of these gives the air requirements per unit of fuel. As in other mixtures, oxygen present in the fuel decreases the necessary oxygen and air supply. An average analysis will show by weight:

Carbon, per cent	84.0
Hydrogen, per cent	15.5
Nitrogen, Oxygen, Sulphur, etc., per cent..	0.5
Total, per cent	100.0

Using this analysis we can conveniently determine the oxygen and air requirements by the following method:

Taking the carbon and hydrogen content separately:

FOR CARBON CONTENT:

$$C + O_2 = CO_2.$$
$$12 + 32 = 44.$$

One pound of carbon requires $\left(\frac{32}{12}\right)$ of oxygen.

0.85 pound of carbon requires 0.2667×0.85 lb. of oxygen. or 0.2266 lb. of oxygen.

FOR HYDROGEN CONTENT:

$$2H_2 + O_2 = 2H_2O.$$
$$4 + 32 = 36.$$

One pound of hydrogen requires $\frac{32}{4}$ lb. of oxygen.

0.155 pound of hydrogen requires 8×0.155 lb. of oxygen. or 0.124 lb. of oxygen.

The total O_2 required will then be: $0.2266 + 0.1240 = 0.3506$ lb. per lb. of oxygen.

The air requirement by weight is $\frac{0.3506}{0.23} = 15.23$ lb.

To obtain the mixture ratio by VOLUME OF LIQUID GASOLINE TO AIR we must know the density of the liquid gasoline and the density of the air.

Gasoline weighs approximately 6.2 lb. per gallon or $\frac{6.2}{231} = 0.0268$ lb. per cu. in.

This corresponds to $\frac{231}{6.2} = 37.3$ cu. in. per pound.

Air at 62 deg. fahr. occupies 13.14 cu. ft. per lb.

From the above we have:

1 lb. of gasoline requires 15.23 lb. air for combustion. Then:

37.3 cu. in. of liquid requires 15.23×13.14 cu. ft. of air for combustion; or

Each cu. in, of liquid gasoline requires $\frac{15.23 \times 13.14 \times 1728}{37.3}$ cu. in. of air = 9280 cu. in.

The use of gasoline of different composition from that given above or assuming air at other temperatures and pressures will modify the above values.

The mixture ratio of GASOLINE VAPOR TO AIR can be obtained from the above, knowing the ratio of volumes of liquid gasoline and gasoline vapor.

One pound of liquid gasoline produces approximately 4.2 cu. ft. of gasoline vapor at 60 deg. fahr., and hence:

Liquid Gasoline vs. Gasoline Vapor

$37.3 \text{ cu. in.} = 1728 \times 4.2 \text{ cu. in.}$

or

$1 \text{ cu. in.} = 195.6 \text{ cu. in.}$

From above:

1 cu. in liquid gasoline requires 9280 cu. in of air for combustion. Therefore:

1 cu. in. gasoline vapor requires 47.4 cu. in of air for combustion.

Practical Proportioning.

The above requirements are for a theoretical mixture and are modified in practice for the following reasons:

Due to stratification, which is always present to a more or less extent, some sections of an engine cylinder charge will be richer than others. There are, therefore, lean, rich and correct portions to each mixture. The actual carburetor adjustment must be made rich enough so that the fuel-impoverished sections of the charge will propagate the flame. This means an enriched charge, but this factor is coordinated with the fact that a certain range of explosiveness is possible with gasoline. The latter influence permits an adjustment with less enrichment even to the extent of air excess. Because of the importance of stratification trouble we find considerable attention given to this matter in a carburetor, manifold and engine design, and numerous instances of static and dynamic devices to produce turbulence.

Another phase of the above, which influences the mixture, as adjusted in the carburetor of a multiple cylinder engine, is that of unequal distribution or stratification between cylinders. In many cases one or more cylinders will be rich (or lean), while all the others have the proper mixture. If this condition is adverse enough to cause missing, the leaning (or enriching) of the carburetor may cause the cylinders that are missing to fire without impoverishing (or enriching) the other cylinders sufficiently to get beyond the range of explosiveness. Aggravated cases of this condition would require a redesign or attention to the mechanical defects which cause them.

Common cases of the poor mechanical conditions producing stratification between cylinders are as follows:

1. Leaky Inlet Valve Stem Guides.
2. Leaky Piston Rings.
3. Leaky Valves.

In any of the above cases satisfactory adjustment could be made if all cylinders leaked the same and within the range of correction by carburetor adjustment. However, these leaks usually vary in the different cylinders and are not constant. In this connection it is interesting to note that mixture ratios taken from a carburetor that performs satisfactorily on an engine in "good" condition show a very rich mixture at closed throttle and close

to theoretical mixture ratio at wide open throttle. This is attributed to air leakage principally through the inlet valve stem guides, which is greatest at closed throttle because of the greater difference in pressure across the guide (Inlet manifold suction 15 to 20 inches of mercury). Such leakage is practically nothing at full load on the engine when the inlet manifold depression may be 0.5 to 1.0 inches of mercury. The carburetor engineer must therefore design the carburetor "wrong" to make it right.

Another factor that influences the mixture ratio is the quality of the fuel and its vaporizability. With gasoline of extremely high end point or mixtures of gasoline and kerosene, a part of the fuel goes into the cylinder unvaporized and as such requires less air for combustion. This is a condition always found when starting cold and demands the use of the choke or carburetor dash control to enrich the mixture. It is estimated that for zero temperature starting with gasoline, about twenty times the fuel must be supplied in order to produce an explosive mixture. As soon as the combustion chamber has had a few explo-

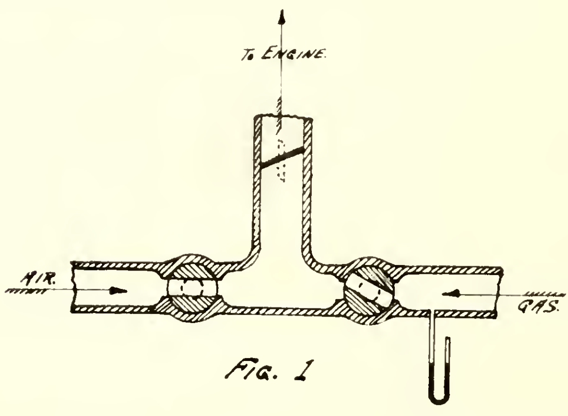


FIG. 1

sions this requirement is reduced to ten or five times the normal fuel supply. Subsequent warming of the engine furnishes a hot air supply, and increasing temperature to the cylinder walls and the hot spot (where provided), and permits normal carburetor adjustments to be used. The above description of starting conditions also furnishes a clue to undue crank case oil dilution. The abnormally rich mixture used condenses on the piston head and is forced by the rings into the crank case. At the same time

the oil is washed from the cylinder walls and is frequently the direct cause of scoring of these parts.

Classification and Description of Devices Used.

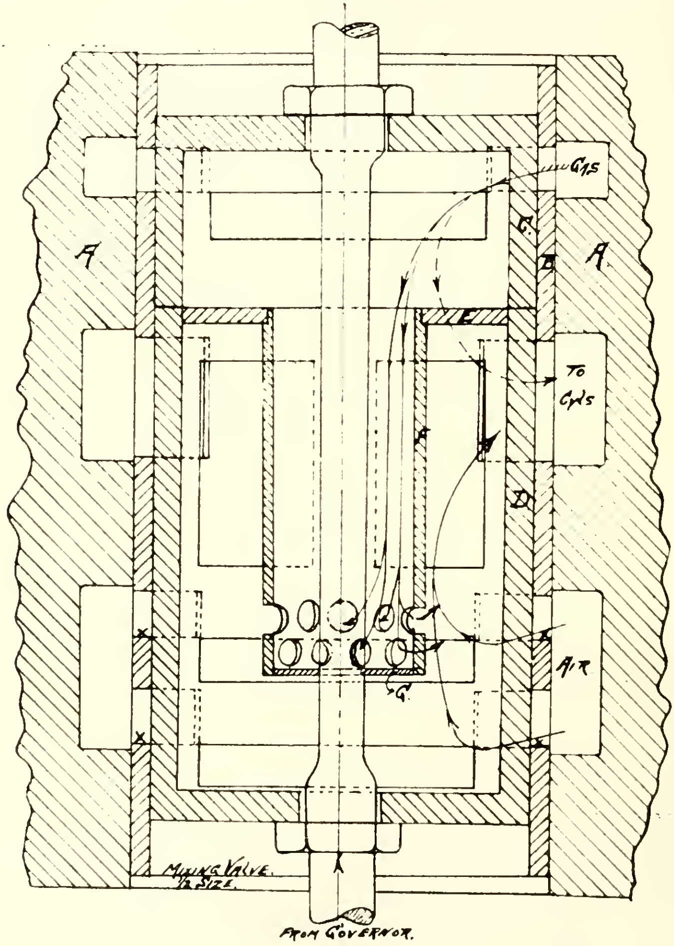
A. For Gaseous Fuels:
   1. Mixing valves. (Often combined with governing throttle valve).

B. For Liquid Fuels:
   1. Injection devices.
      (a) Dependent entirely on heat of compression for ignition.
      (b) Dependent on hot bulb or hot plate for ignition.
   2. Oil gas producers combined with mixing valve.
   3. Vaporizers or generators.
   4. Atomizers or carburetors.
      (a) Surface.
      (b) Puddle.
      (c) Spray.

C. For Solid Fuels:
   1. Gas producers for coal, peat or wood.
   2. Air contact generators for solidified gasolines or alcohols.
      (Use a mixing valve of some kind to proportion the charge correctly).
   3. Direct injection of powdered fuels or colloidially suspended fuels.

Fig. 1 shows an elementary form of mixing valve for gaseous fuels. The gas and air cocks are regulated so that an explosive mixture leaves the device and enters the engine. To maintain constant proportions, the gas is usually regulated to approximately atmospheric pressure at its regulating cock. This is effected by a pressure regulator or gasometer. With gas at a higher pressure than atmospheric the mixture would be rich at light loads and lean at heavier loads. Maintenance of this gas pressure at about zero gauge is of utmost importance when an engine operates at varying load, but good results can be obtained for any uniform gas pressure if the demand of the engine is constant. The usual permissable allowance is + or — 0.5 inch of water.

Fig. 2 shows a successful mixing and throttle valve combined which is suitable for clean gases. Dirty gas or air will cause the close fitting cylindrical valve to stick. Dirty oil will produce the same results and cause irregular governing action. A is the manifold casting with a machined bushing, B, pressed in place. This construction permits the parts in the bushing to be machined accurately. The valve C-D is in two parts and held together by the center bolt. The lower extension of this bolt connects to the



governor, which can then move the valve axially. Rotation of either part C or D can be made independently to give varying

amounts of gas or air. These pass to the center of the valve and then to the manifold, as indicated by the arrows. The valve as originally made did not have the parts E, F and G and gave a stratified mixture. The added parts forced the gas to go to the lower part of the valve and out of the small holes, where it intimately mingled with the larger air volume. These changes produced a smoother running engine and lower fuel consumption.

The desired mixture is hand regulated for the correct gas port opening. After this setting is made the governor action opens or closes these ports proportionately and maintains the mixture (as adjusted by hand) for all loads on the engine. The cutting off edges of the ports must be identical or the mixture ratio will change at light loads. Conditions like this are sometimes produced by dust in the air piling up at X X X X, especially when oil is present at these points. A stop is usually provided which limits the closure to port openings just sufficient to operate the engine with no load. This prevents missing and hunting under varying loads.

For Liquid Fuels other arrangements have been devised which can be classified as follows:

Injection of the liquid fuel into the cylinder is used in the Diesel engine, and combustion begins as soon as the fuel comes in contact with the highly heated air. The air must, of course, be above the spontaneous ignition point of the fuel. The required temperature is obtained from the heat of compression, which is from 900 to 1100 deg. Fahr., with compressions of from 500 to 550 lb. per sq. in. In order to more completely atomize the fuel and reduce stratification and slow burning, this liquid fuel is injected with higher pressure air. This effectively subdivides the fuel and distributes it through the air for combustion. The atomization is accompanied by a slight refrigeration effect.

A somewhat similar arrangement is used in the Hvid type of engine, wherein the liquid fuel is first introduced into a "cup" of relatively small volume and which is in communication with the main combustion chamber. The construction therefore does not require a separate air supply for fuel injection. Compressions of 400 to 425 lb. per sq. in. are practical for kerosene. Sufficient temperature rise from compression is obtained to start and operate on this cycle.

The Semi-Diesel and Hot Bulb types have also come into extensive use, permitting of lower compressions but requiring some local hot spot in the combustion chamber to effect sufficient temperature rise for igniting the fuel. Provision for starting cold may include an electric spark plug, a hot wire or preliminary heating by a torch or a hot bulb. Control of the point of ignition if influenced by the temperature of the jacket water or air and by the load on the engine. The Semi-Diesel may have from 150 to 300 lb. per sq. in. compression, while the hot bulb type is usually lower and may be 50 lb. per sq. in.

The use of liquid fuels in internal combustion is sometimes accomplished by first cracking these fuels with heat and then using the gaseous fuel formed as described above. Oil gas producers can in this way supply gaseous fuels for other purposes. A somewhat similar arrangement is used when lighter fuels are available. The heating them vaporizes the fuel without cracking, and it can be mixed directly or in two stages with the required air. The two-stage method has the advantage of facilitating the transfer of the rather unstable fuel through the necessary piping. Condensation of the fuel must be carefully guarded against. The engine jacket water or exhaust gases are used for this heating.

The most extensively used devices for proportioning liquid fuel and air, before introduction into the engine are the carburetors or atomizers. These use the relatively lighter fuels, as gasolines and kerosenes. For the very light gasolines the Surface or Puddle types of carburetors are satisfactory. The air in passing over or through the fuel is sufficiently enriched at ordinary temperatures to produce the desired mixture ratio. An objection lies in the more rapid evaporization of the lighter elements while the heavier constituents of the fuel remain behind and accumulate in the bowl of the mixing device. The Spray types of carburetors, however, use a considerably greater range of fuels and have hence practically replaced the surface or puddle types. One of the requirements for good mixtures is the thorough distribution of the fuel in the air. The mixture must be homogenous to give quick and complete burning. The higher the engine speeds the more imperative this requirement. With stratified mixtures the burning becomes slow and incomplete, re-

sulting in lower power, greater fuel consumption and a greater loss of heat to the water jackets. The latter item is directly caused by the greater cylinder wall exposure to the lingering flame. In some cases the flame dies out while attempting to propagate itself through the charge which is too lean or too rich in parts. This problem of intimately mixing the fuel and air is more difficult with such fuels as gasoline (approximate mixture ratio 1 to 9000 by volume) than it is with fuels such as natural gas (approximate mixture ratio 1 to 10 or 12). It can be compared in the case of mixing liquid gasoline with air to attempting a mixture of uniform color with a bottle of India ink and a tub of milk. The elimination of streaks requires energetic stirring. A natural turbulence is usually incorporated in the carburetor, and manifolds are often designed to augment this characteristic.

TYPICAL PRACTICAL MIXTURE RATIOS.

FUEL		FUEL TO AIR
Natural Gas	(Volume to Volume)	1-11
Natural Gas	"	1-7
Water Gas	"	1-3
Coke Oven Gas	"	1-6
Producer Gas	"	1-1.25
Blast Furnace Gas	"	1-1
Gasoline Liquid	"	1-9000
Gasoline Liquid	(Weight to Weight)	1-15
*Gasoline Liquid	(Weight to Volume)	1-200
Gasoline Vapor	(Volume to Volume)	1-53
Benzol	(Weight to Weight)	1-14
Alcohol	"	1-10

*Lb. to cu. ft.

*MAKING WORK A GAMF

By L. K. Sillcox.

The following inspiring address was made by the general superintendent of motive power of the Chicago Milwaukee & St. Paul Ry. to the Railway Club of the University of Illinois, December 16. It is a timely introduction to the coming holiday season—a time for careful meditation and resolution, but it is also good for all times. Play the game and make good!

When it came to choosing a subject, the one selected seems to briefly sum up my experience since entering the vocation of railroad life and it would be my purpose tonight to take a few leaves from the book of experience and present them in a frank and faithful manner.

It is well to remember that all growth depends upon activity, and life is manifest only by action. Furthermore, there is no development physically or intellectually without effort, and effort means work. Work is not a curse, it is the prerogative of intelligence, the only means to manhood and the measure of civilization. The degree of success which one may attain is not merchandise or position or anything else but character, and it is, therefore, important to determine at any time not so much where we are, but exactly whither we are going.

In railroad activity we are brought face to face with the varying human quantity on account of the diversity of the work, more than in any other field. The success of a railroad in the end is largely patterned after the fashion of a mans career, and therefore, depends upon the character and effectiveness of service rendered by each individual composing the organization. The personal example set by those in authority is of vast importance, and education through intimate contact of officers with men serving in their departments in an honest endeavor to bring home to each one the critical situation in reference to transportation matters, is very necessary, so that a true realization of personal responsibility may be had, and thus obtain adequate return in honest endeavor for every expenditure made in the handling of the business offered.

*Reprinted from the "Railway Review."—12-25-'20.

Faith in the Individual.

A true preventative of labor difficulties is to be found in the cultivation of a good understanding between employees and their officers. In these days, grave problems have to be faced in the railroad and industrial world and we can readily see that their only solution lies in keeping before us fundamental virtues and an endeavor should be made to avoid some of the most familiar and most undesirable of the traits to which mankind has owed untold degradation and suffering throughout the ages. America is built on faith in the individual, faith in his will and power to do right of his own accord, but equally in the determination that the individual shall be protected against whatsoever force may be brought against him. We believe in him not because of what he has, but what he is. Good will come out of the present evils if we face them armed with honesty of purpose, demonstrating that we are fearless of soul, firm in time of necessity, and if we exert a kindly disposition to talk without the betraying weakness that cringes before wrong-doing, and showing by deeds and words our knowledge, that in such a government as ours, each of us must personally bear a sense of duty to the nation.

I speak in this way, because, if college bred men are to exercise an influence over the progress of the world which is their portion, they must exhibit in their lives a knowledge and a learning which is *marked with candor, humility and the honest mind.* In these days of violent agitation, scholarly men should reflect that the progress of the past has been accomplished not by the overthrow of institutions, so much as discarding that which was bad and preserving that which was good, all in a sense of evolution; unless such a plan is adhered to, we should have missed the central feature in all progress.

There is a natural desire in every human mind to seek better conditions, and such is highly praiseworthy, but there must be discrimination in the methods employed. Wholesale criticism of everybody and everything does not necessarily exhibit honorable qualities and may not be true. On the other hand, we must always have an alert and interested citizenship and in order to obtain it, we must look to ourselves not in expectation of a reward, but with a desire to serve, realizing that out of government we obtain exactly what we put into it. It is the part of educated men to know and recognize these principles and influences, and

knowing them to warn their fellow countrymen, many of whom have not had adequate opportunity to truthfully and impartially judge facts for themselves.

How Responsibility Comes to Men.

As you men advance, you will find that responsibilities will crowd in upon you according to the measure of progress realized. Our nation today needs the help and assistance of every well-informed man, to first see that in his own experience, he is doing all that he can for the best interests of advancement, and at the same time, is endeavoring to inform along proper lines those who are so easily misled and who have not had the advantages of higher education. This will often require extreme courage, but it is the part of real men to play.

It may be wondered just why I have used this sort of a preliminary discussion and it would be better explained if I could tell you what a large portion of a railroad officer's time is taken up in dealing with *the human side of the service;* that is, especially in these days; the purpose being to try and have employees function since railroad managements are doing their utmost along honest lines to obtain reciprocal response. Unless this can be realized in full measure, no railroad can really socceed. From this you can see that an officer, no matter how highly educated he may be, unless he has schooled himself to be a real fellow, can never hope to succeed and get the best from his subordinates. I commend this thought to you and ask that any man who leaves this university to take up railroad work, or in fact any occupation, that in his ten, fifteen or twenty years' apprenticeship to become an officer, that he fail not to study men from day to day and endeavor to learn from those with whom he associates, to store up and build upon his best and most lasting experience. If this is done, there is no question that with the equipment of a good education and a manly conduct, future success is bound to become a realization.

Any college man going into railroad service on a large system, must successfully compete with a vast number of energetic, earnest, honorable men who have not had the advantages which he has enjoyed and this is an appeal to every college man entering railroad service to try and be doubly careful, not to lay undue weight on the question of his education, as compared to his neigh-

bor's. This can be brought into play later, as an executive, far better than in the probationary years in the shop as a junior officer, because much more is expected from the college man and less excuse would be accepted from him for failing to function, than would be true of his neighbor, who had not been given these advantages.

Mechanical Department a Place for Young Men.

In the mechanical department on the railroad with which I am connected, we have many splendid university men who are doing wonderfully good service; a number are running locomotives and for reasons known to themselves have not aspired to executive positions, yet their influence is tremendously beneficial in the field where they serve. We have other men who are steadily advancing and are a great credit to themselves and our company; in fact, they are indispensable on account of the services they have been able to give. Recently, it has been necessary to promote a number of technical graduates, but the supply of mechanical men on the railroad has not been sufficient, with the result that we are breaking in civil, electrical and mining engineers to mechanical positions, these men having served many years with our property. I mention this for the reason that there are places for university men on the railroads today and there is as much opportunity as in the past, but college men must make themselves fit and work out their plans in such a way that they will obtain access to these promotions and conduct themselves in such a manner through *power of example* that they will be found indispensable to the service.

There are many problems which are being given serious thought at this time where the best possible education is required, and where men who have been trained to think clearly along local lines, are needed.

Taking the locomotive problem, for instance; the immediate need is to provide more power without imposing additional strains on roadway or structures. Further than this, there is a transportation requirement in the improvement of design and method of operation which will reduce road service failures. The question of motive power management to bring it parallel with those methods which have resulted in the greatest success to the handling of vast industrial establishments is receiving

serious thought. Surely the motive power problem presents possibilities as great as those in any field of engineering activity and they are worthy of thought and consideration, as a life task, to any man. The motive power officer on any large system and his assistants live a very busy life as compared to past experience and there are great questions of shop management, the economics of operation, and most of all the labor problems, which have to be dealt with from day to day. Power has to be designed, prepared and maintained to carry trains a mile long with existing facilities. Records of performance and cost of work must be carefully reviewed and checked in detail.

The economics, both technical and commercial, surrounding the operation, maintenance and design of railway equipment is an enormous problem in itself and requires intimate knowledge of detailed service so far as it relates to any particular road or territory. The motive power and car departments of railroads disclose a two-fold purpose: The technical work which is the basis of all design and methods in repair and maintenance and of all those means which are employed by the engineer to insure freedom from failure and economy in operation; secondly, there are matters of administration, having to do with men, and with all of those features which are essential in securing their prompt and harmonious action. The one is the work of the engineer, the other the work of the business man. While any motive power department must perform both of these functions, it may within limits emphasize one or the other, and evidence is not lacking which shows a tendency in present practice to slight the technical and to emphasize the administration.

The Tasks Ahead for Young Engineers.

To be successful in either of these branches, wide experience is necessary. It is into the engineering branch that technical school graduates are most likely to drift, the work being not only agreeable but closely allied to the student's experience at school. Without in any way reflecting upon the opportunities offered in the line of mechanical engineering, it should be said that experience, either in the shops, repair yards, or in the roundhouse, is important for a man who is to succeed. It seems positively desirable to recommend men to delay entering the engineering work until they have had experience in one or more of the other

branches. If they are by temperament and ability qualified for either shop or road administration, they will learn this fact most easily and quickly in connection with the actual contact, and if they are better fitted for engineering service, they will be better able to handle them later on, because of the road or shop experience. It seems in general, desirable for men to avoid the technical branches immediately upon completion of their college course.

In studying the careers of successful men, a prominent fact is developed, which seems specially applicable to railroad men. Those who have actually advanced most rapidly and have risen highest, have usually advanced slowly during the first ten or more years. It is believed that an attractive future has been pictured for those who prepare and equip themselves in the right way to carry the mechanical railroad burden of the future. It most assuredly will pay to prepare thoroughly and well, for which years of experience are required.

For men to succeed, it is merely necessary to "make good." Every railroad official is looking for men who may be trusted to do things. The official does not need to be told who can do them. A man makes his record by work itself. He should seek opportunities to do things that somebody wants done. Of these opportunities, railroad mechanical department work is full beyond measure.

TRUCK MAKES 24-HR. NON-STOP RUN

In a recent test made upon the Indianapolis, Ind., Speedway, a stock model of the Duplex truck, loaded with gasoline, oil, and ballast and weighing 8,300 lbs., exclusive of the drivers, made a 24-hr., non-stop run at an average speed of more than 38 miles per hour, running the total distance of 930 miles between 1:57 P. M. September 30, and the same hour the following day.

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UNUSED TOOLS

Perhaps the best known engineer in the United States today, aside from such inventors as Edison and Steinmetz, is Herbert Hoover. There are many, however, who do not know that he is an engineer. Hoover's reputation rests on his relief work in Belgium and on his administration as Food Director during the recent war. It is only the technical man who recognizes him as America's foremost mining engineer and as president of the Federated American Engineering Societies. Yet this man is one of the few of his profession who have risen above purely tech-

nical work, and are using their trained minds to direct great enterprises.

That this should be the exception rather than the rule in this day of great industrial activity, seems strange. Many of our great enterprises have sound engineering practice as the very foundation of their success. Such are the steel industry, the oil business, the railroads, the lumber enterprises, the automobile business, and many others. Yet at the head of the United States Steel Corporation is Judge Gary, a lawyer; the leading spirit of the Standard Oil Company was H. H. Rogers, a business man; James Hill, the founder of the Great Northern Railroad, was an operating man; and Edward Hines, the lumberman, started as a salesman. These instances can be duplicated in nearly all of our great industries. The engineer, whose knowledge is necessary for their success, is not at their head.

The reason for this state of affairs is not hard to find. The man who holds the executive position of a great industry must have a variety of characteristics. He must first have a detailed knowledge of his own business. He must be able to make quick decisions. He must be an excellent judge of men. He must possess great tact. Above all else, (and it is here that the engineer has failed) he must thoroly understand the business world of today, and particularly its relation to his own industry. This entails a knowledge of banking, of insurance, of investments, of marketing securities, and of foreign trade. Such a man cannot afford to be made the plaything of his competitors. He must see all of the phases of his business.

The engineer to date has been so intent upon his technical problems that he has either passed by or neglected this other factor so necessary to his success. The colleges cannot be blamed for this state of affairs, for their purpose is to teach the basic laws upon which all engineering rests, and to point the way to their application. Even here, those subjects dealing with business principles are the most neglected. The fault lies clearly enough in the limited interests of the engineering student.

Today the technical man stands as one in possession of a valuable tool that is useless for want of sharpening. The emery is at hand, too, for our libraries are full of books on business principles; our magazines and newspapers devote pages to them; our schools give varied courses in the related subjects; and busi-

ness methods are the constant talk of all men so engaged. If the engineer wishes to assume his deserved position as a leader in modern organized society, he must recognize this need of a business training, and supply it.

THE SECRET OF THE MACHINES

(Modern Machinery)

We were taken from the ore-bed and the mine,
We were melted in the furnace and the pit,
We were cast and wrought and hammered to design,
We were cut and filed and tooled and guaged to fit.
Some water, coal and oil is all we ask,
And a thousandth of an inch to give us play:
And now if you will set us to our task,
We will serve you four and twenty hours a day!

We can pull and haul and push and lift and drive,
We can print and plough and weave and heat and light,
We can run and jump and swim and fly and dive,
We can see and hear and count and read and write!

Would you call a friend from half across the world?
If you'll let us have his name and town and state,
You shall see and hear your crackling question hurled
Across the arch of heaven while you wait.
Has he answered? Does he need you at his side?
You can start this very evening if you choose,
And take the western ocean in the stride
Of seventy thousand horses and some screws°

The boat-express is waiting your command!
You will find the Mauretania at the quay,
Till her captain turns the lever 'neath his hand,
And the monstrous nine-decked city goes to sea.

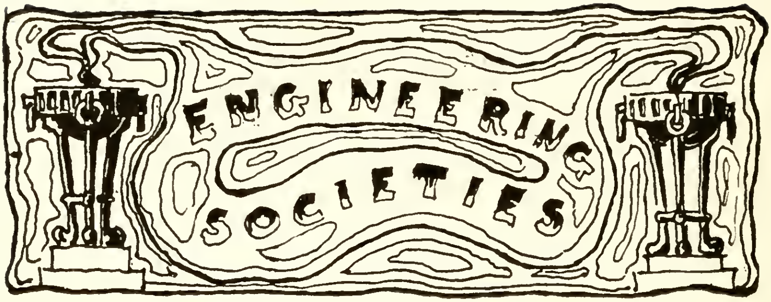
Do you wish to make the mountains bare their head
And lay their new cut forests at your feet?
Do you want to turn a river in its bed,
Or plant a barren wilderness with wheat?
Shall we pipe aloft and bring you water down
From the never failing cisterns of the snows,
To work the mills and tramways in your town,
And irrigate your orchard as it flows?

It is easy! Give us dynamite and drills!
Watch the iron-shouldered rocks lie down and quake
As the thirsty desert level floods and fills,
And the valley we have dammed becomes a lake.

But remember, please, the law by which we live,
We are not built to comprehend a lie,
We can neither love nor pity not forgive,
If you make a slip in handling us you die!
We are greater than the Peoples or the Kings—
Be humble, as you crawl beneath our rods!—
Our touch can alter all created things,
We are everything on earth—except the Gods.

Though our smoke may hide the heavens from your eyes,
It will vanish and the stars will shine again,
Because, for all our power and weight and size,
We are nothing more than children of your brain.

Rudyard Kipling.



THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Charles T. Walter .... *President*
John P. Sanger .... *Vice-President*
Robert W. Van Valzah............ *Treasurer*
William A. Heitner .... *Secretary*

The meeting schedule adopted by the A. S. M. E. was rigorously adhered to, as was the policy of calling on members for short talks.

Mr. J. P. Sanger gave a snappy talk on "Cost Accounting." He touched on:

1. Cost of Finished Product.
2. Cost of Individual Operation.
3. Overhead Charges.
4. Sales—
   (a) Home Markets.
   (b) Foreign Markets.

Mr. S. N. Havlick gave a comparative talk on the "Systems of Assembly." The discussion compared the operations consisting of minutes and seconds, as is illustrated by the "Ford" system, against operations taking an hour or more. This led to a lively discussion pertaining to the psychological effect of the "Ford" system on the men.

Mr. C. B. Doolittle described the proposed Ford Power Plant at River Rouge. He laid special stress on the type and design of the boilers, which are so immense that they might easily be

termed superboilers, the combustion chambers being so large as to easily accommodate eight standard Ford cars.

He also discussed the feasibility of making castings from the metal taken directly from the blast furnaces.

Mr. A. Hoven's talk, "Planning in a Factory," proved very interesting and instructive. He described a system used for planning the work for machines, and the recording of data sufficient to re-manufacture the articles at some future time.

Other interesting topics were: "Methods of Saving of Coal Due to Unnecessary Losses in Boilers," by Mr. Naiman; "Intake Manifold Design, and Fuel Control," by Mr. H. W. Bird; "Diesel Engines," by Mr. S. Webster, and " A Trip Through a Gas Plant," by Mr. F. Quinlan.

This latter topic proved very interesting since Mr. Quinlan has served the Gas Company in various capacities for several years and is an authority on this subject.

The A. S. M. E. is accomplishing its purpose and results are forthcoming. Wm. A. Heitner, Secretary.

THE ARMOUR CHEMICAL SOCIETY

President ....E. F. Winter
Vice-President ....J. W. McCaffrey
Secretary ....W. J. Savoye
Treasurer ....H. W. Ahlbeck

The Armour Chemical Society has held but one important meeting since the last "Engineer" went to press. This was on Jan. 4, 1921, when Mr. Herbert Sieck, '11, gave a very interesting talk on "Cocoanut Oil Refining." Mr. Sieck had with him the flow sheet of the plan of manufacture, and samples of the oil at various stages of the process. Every man present was much interested, and the Society wishes to thank Mr. Sieck most heartily.

The president wishes to announce that he has several instructive talks planned for the future. On Feb. 15, Mr. David Lesser, '14, of the Goldsmith Smelting & Refining Company, will talk on "Secondary Metals; Refining and Smelting." The place will be Science Hall, and the time four o'clock. All students who are interested in this subject are urged to be present.

W. J. Savoye, Sec.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

In accordance with the plans adopted at the first meeting of the society, regular meetings of the Armour Branch of the A. I. E. E. have been held every two weeks, at which the student members were the speakers. The program has been as follows:

Nov. 5, 1920.

Types of Electric Furnaces, by R. J. Grant.

Theory of the Vacuum Tube as Used in Radio Work, by W. W. Pearce.

Electrical Apparatus for Unloading Vessels, by A. R. Mehrhoff.

Nov. 19, 1920.

Burning Out a 750 Volt Turbo Alternator, by R. C. Grube.

Discussion by D. S. Chase, L. S. Bloom, and T. L. Albee.

Dec. 10, 1920.

The Lake Front Improvement, by J. J. O'Rourke.

Machine Switching Telephone Boards, by G. H. Kelly.

Development of Synchronous Convertors, by T. L. Albee.

Dec. 13, 1920.

Ardois System of Signalling, by F. V. Walters.

Gas Engines As Prime Movers, by R. J. Grant.

* The Outlook for the 1921 Graduates, by Leslie Weiss.

Jan. 7, 1921.

Regular meeting, followed by a smoker in the Y. M. C. A. rooms. Speakers at the smoker included Prof. Freeman, and two graduate engineers.

The A. I. E. E. is going into things with a snap this year. The plan of student talks is proving a great success. Every member of the Armour branch is gaining valuable knowledge and experience in giving these short talks, and all have proved willing to accept a share of the responsibility. The year of 1920-1921 is proving one of the best years experienced in the history of the branch.

T. L. Albee, Sec.

* Leslie Weiss, an Armour graduate of 1918, took the General Electric Company's Training Course at Schenectady, and is at present in the managing department of a hydro-electric development in Pennsylvania.

THE FIRE PROTECTION ENGINEERING SOCIETY

President ....*W. E. Kingsley.*
Vice-President ....*W. W. Oakc*
Secretary ....*J. W. Roddick*
Treasurer ....*E. W. Geisler*
Chairman of Social Committee..*R. R. Maguire*

The Fire Protection Engineering Society, which has been dormant since the period of the war, was reorganized on November 15. President Kingsley delivered a very unique opening address, setting forth the object and aims of the society, after which the main business was discussed. A committee was appointed to revise the constitution to meet the present needs.

Prof. Finnegan, head of the department of Fire Protection Engineering, gave an interesting talk on the need of technical men in the insurance field.

The outlook for the society for the coming year is very bright, due to the presentation of twenty-five scholarships a year by the Western Actuarial Bureau. This large increase in the Fire Protection course will mean a great deal to the future of the society, since all the men are here for a definite purpose. The new men have shown their interest in the society by being present at the first meeting, which was a great success.

J. W. Roddick, Sec.

THE WESTERN SOCIETY OF ENGINEERS

Since the writing of the report of the activities of our society for the last issue of the "Engineer," we have held two very profitable meetings. At the first of these, Dean Monin gave us a very instructive and, as usual, interesting talk on some of his vacation experiences, and also talked on other matters of value to prospective engineers. It was to be regretted that a larger number of our members did not attend.

The other meeting, after the regular business had been carried out, consisted of a discourse on "Sewage Disposal" by Mr. Langdon Pearse, Chief Engineer for the Sanitary District of Chicago. His talk consisted of an explanation of the modern methods of taking care of sewage in general, and as particularly

applied in Chicago. Those present must certainly have gained some new ideas, or a clearer conception of those ideas which they possessed before hearing Mr. Pearse. He made the statement, which may be repeated for the benefit of all of us, that a successful engineer must be a diplomatist and must have a knowledge of politics in order to make possible necessary construction in many cases.

A number of our members have changed from participating to student members in the parent body of the W. S. E., and eighteen participating members have been added to our roll.

Mr. A. Appelbaum has been elected Secretary to take the place left vacant by the resignation of Mr. W. K. Lyon, with Mr. E. M. Seaberg as Assistant Secretary.

The year 1920 has seen our organization expand and become an important cog in the Department of Civil Engineering, and we look forward to a continuation and enlargement of our previous success during the coming year. E. M. Seaberg.

THE ARMOUR ARCHITECTURAL SOCIETY

Massier ....Theodorus M. Hofmeester
Secretary ....Helen L. Fassett
Treasurer ....Edmund J. Ryan

On Monday, November 15, 1920, the Armour Architectural Society held its annual initiation and banquet in the club rooms of the Art Institute. As is expressed by the old quoted phrase, "an enjoyable time was had by all," including the initiates. No casualties were reported and all of the Freshmen were able to be seated at the banquet table.

The Speaker of the evening was Andre' N. Rebori, the noted Chicago architect. Mr. Rebori gave a very interesting talk, touched often with his genial humor and pleasant satire. He was followed in order by Mr. Cambpell, Mr. Krehbiel, and Mr. McCaughey, who each gave a few words of sound advice to the initiates.

The architects are justly proud of their showing in the recent New York Competition where Massier Hofmeester won a second medal, and four other Seniors took Mentions. A second problem

has been sent in which has not yet been judged. The subject is "A Monumental City Hall Staircase." It is hoped that even more honors shall be gained at this judgment.

The Society is planning to give a dance in the near future in the club rooms of the Art Institute. A cordial invitation is here extended to all engineers to be present at this event.

ARMOUR RADIO ASSOCIATION

The A. R. A. has been very fortunate in being able to have some very interesting talks by members who have had commercial operating experience. The radio amateur is always interested in commercial apparatus whether of Marconi or Navy type.

The fourth regular meeting of the association was held November 10, 1920, in the Physics Lecture Room. The first business before the meeting was the appointment of a program committee. President Goodnow thereupon appointed the following as members of this committee:

Mr. A. R. Mehrhof.
Mr. G. H. Kelley.
Mr. J. W. Falconer.

The president called upon Mr. Mehrhof for an impromptu talk. Mr. Mehrhof responded with a talk covering the description of the new Marconi cabinet type transmitter as installed on ship stations in the Great Lakes region. The new apparatus is of the 500 cycle multiple quenched spark type. The entire set with the exception of the transmitting key and motor-generator set is mounted in a cabinet which does not occupy more than a cubic foot of space. The novel feature of this new apparatus is the combination change-over switch mounted on the front panel. This switch not only effects the transfer of the antennae from the receiving to the sending set but also starts the motor generator set in operation. The new transmitter is rated at one-half K. W. imput and has a conservative range of 150 miles.

The speaker also stated that the carborundum detector is standard equipment on all Marconi receiving sets. In these circuits it is always used in conjunction with a potential rheostat and battery. This detecting device is not very highly respected by amateur operators since the introduction of vacuum tubes, but

Mr. Mehrhof defended the carborundum detector on the ground of stability of operation. He stated that it was practically impossible to use an ordinary galena crystal on shipboard because engine vibration and other disturbances prevent the permanency of a sensitive contact which is absolutely necessary.

President Goodnow also called upon Mr. E. Sanborn for a short talk covering his commercial experience in the navy during the war. Mr. Sanborn had some very interesting experiences with submarine radio. He gave some confidential sidelights on the comparative efficiency of Marconi and Telefunken apparatus. He found that the two K. W. Marconi transmitter would radiate about seventeen amperes on overload while a Telefunken transmitter rated at one-half K.W. would normally give the same radiation. This showed conclusively that the latter type is the more efficient radiator. The new submarine aerial developed by the Navy Department during the war was also described in detail. The unique feature of this submarine loop aerial is the utilization of the frame of the submarine as part of the loop. Mr. Sanborn also gave some exceedingly humorous instances of the precarious risks assumed by a submarine crew. One member became entangled with the antennae wires while doing some heavy work, and was nearly electrocuted when the radio operator began transmitting without giving the usual warning.

The fifth regular meeting of the association was held December 15, 1920, in the Physics Lecture Room. The association enjoyed a very interesting talk on the timely subject of heterodyne reception by Chief Operator Hultgren. As evidence of the importance of this particular phase of radio to operators he cited the fact that at least two amateur stations in the vicinity of Chicago have had no trouble in receiving radio telephone music from special amateur stations as far east as Pittsburgh, Pa. Mr. Hultgren explained the fundamental theory of heterodyning by the use of a simple crystal detector circuit which was inductively coupled to a high frequency alternator. He then clearly showed how a vacuum tube is used in a modern self-heterodyne receiver wherein a single tube performs simultaneously the three functions of detector, amplifier and local oscillator.

Ralph Kendrick, Sec'y. A. R. R.

COLLEGE NOTES

ATHLETICS

Basketball opened up athletic activities in the Armour Institute of Technology for the season 1920-21. The college has booked games with a number of strong teams as is shown by the following schedule:

American College of Physical Education—at Armour	Nov. 30
Butler College—Indianapolis, Ind.	Dec. 3
Indiana University—Bloomington, Ind.	Dec. 4
Hahnemann Medical College—at Armour	Dec. 10
Illinois Wesleyan University—at Armour	Dec. 17
Chicago College of Osteopathy—at Armour	Jan. 7
Notre Dame University—at Armour	Jan. 12
Chicago Technical College—at Armour	Jan. 14
Valparaiso University—Valparaiso, Ind.	Jan. 17
Lake Forest College—Lake Forest, Ill.	Jan. 19
Augustana College—Rock Island, Ill.	Jan. 27
American College of Physical Education—Chicago, Ill.	Feb. 1
Lake Forest College—at Armour	Feb. 8
Notre Dame University—South Bend, Ind.	Feb. 11
Elmhurst College—at Armour	Feb. 16
Illinois Wesleyan University—Bloomington, Ill.	Feb. 21
James Millikin University—Decatur, Ill.	Feb. 22
Augustana College—at Armour	Feb. 25

This year's basketball team is being coached by W. E. Johnson and consists of the following players:

S. Havlick (Capt.)	Guard	P. Witashkis	Forward
H. Ahlbeck	Forward	E. Johnson	Guard
G. Schumacher	Forward	E. Payson	Guard
C. Sippel	Center	A. Zalewski	Guard
D. Rutishauser	Center	A. Fischer	Guard
O. Kuehn	Forward	S. Farrell	Forward

The initial game of the season was played with the American College of Physical Education on November 30. The Institute

team won this game by a score of 33 to 21. In this game Ahlbeck and Schumacher starred for Armour, the former making six baskets and the latter four.

The Institute players made a trip to Indiana and played Butler College on December 3. The two teams were well matched and alternately held the leading score until the latter part of the second half when Pat Page's team made a series of long field goals. The final score was 32 to 23. The following evening the Institute team met the University of Indiana team on the latter's floor, and was defeated by a score of 16 to 48, by the strongest team in Indiana and probably in the Big Ten Conference.

On December 10 the Institute team met the Hahnemann Medical College team in the Armour gymnasium. This game was a decided victory for Armour in every detail as is shown by the score, which was 34-14. Ahlbeck increased the Tech score considerably by making seven baskets and six free throws. Close guarding by Johnson and Havlick kept the Medics away from their goal and forced them to take long shots at the basket which they failed to make.

The University of Chicago booked a game with Armour on December 15, in Bartlett Gymnasium. The Tech team played a remarkable passing game, and led the Maroons by a 2 to 0 score for several minutes after the starting whistle. Due to a strong Maroon defense the Institute players were unable to get within range of the basket for many shots, and Chicago soon took and held the leading score. The splendid following that the Institute had, which consisted of several hundred students and a fifteen-piece band, illustrated the manner in which the college is backing the team.

On December 17 the Institute team played the Illinois Wesleyan University at the Armour gymnasium and was defeated for the first time this season on their own floor. The victory for Illinois Wesleyan was gained principally by long field goals. Houssler of the Wesleyan team made the greater number of these for the visitors. Illinois Wesleyan is a member of the Little Nineteen Conference and is probably the strongest team in that league.

Armour Institute played a second game with the University of Chicago on January 3, in which the most accurate "basket shooters" of the Maroon team were held to a few baskets. Due to the strong guarding and to the Tech players' ability to find

the basket the final score was 15 to 34 in favor of the Maroons.

When the Chicago College of Osteopathy came to Armour they found the team in good condition, well able to find the basket and skilled in passing the ball. Schumacker made eight baskets and Havlick added eight more points to the score. Ahlbeck, Rutishauser, Sippel, Johnson, Payson and Fischer showed their ability to break through the defense of the Osteopaths.

It is anticipated at this time that the basketball team for the year 1920-21 will win the majority of their games, although they are carrying a heavy schedule. Greater enthusiasm for athletics has been shown this season than ever before and is illustrated by the large attendance at the games. We earnestly hope that the intense interest among the students in the Armour Institute of Technology for the promotion of athletics will continue to exist.

THE NEW YORK COMPETITION

Few of the engineers realize the position that our Architectural Department holds in the intercollegiate world, but an event has recently occurred which forces attention in their direction.

There is held in New York five times a year, what is known as the Beaux Art Competition. All of the Eastern colleges and some few of the Western, send problems there to be judged by prominent New York architects. The nature of these problems is announced in advance, and a definite time is allowed for their completion. The rewards given are First Medal, Second Medal, First Mention, and Mention, in the order named. To win in this competition is counted a great honor, and requires real talent, for there are drawings entered from all parts of the country.

This year is the first that Armour has entered in the competition, and we are quite proud of the results. T. M. Hofmeester, Massier of the Architectural Society, won a second medal on his presentation of "A Country Estate," which was the problem judged on November 16th. Mentions were taken by five other Seniors: I. Jerry Loebl, Norman J. Schlossman, Helen L. Fassett, George D. Conner, and Rudolph Nedved.

A second problem has been presented that has not yet been judged. The subject was "A Monumental City Hall Staircase,"

and some very creditable drawings were presented. We hope that in this second competition, our architects may add still more glory to their name.

TAU BETA PI

Tau Beta Pi, honorary engineering fraternity, announces the initiation of the following Seniors into its membership: M. O. Brueckner, F. Duennes, F. E. Hayden, W. A. Heitner, J. J. O'Rourke, D. L. Rosendal, C. T. Walter, S. H. Webster, and R. W. Van Valzah.

LIST OF THESES TO BE PRESENTED BY THE SENIORS OF THE MECHANICAL ENGINEERING DEPARTMENT.

"A Proposed Design of the Air Testing Laboratory for The Greater Armour Institute of Technology."

Charles T. Walter.

"A Proposed Design of the Refrigeration Laboratory for The Greater Armour Institute of Technology."

Alfred C. Hoven.
R. W. Van Valzah.

"The Performance of a Harrington Forced Draft Chain Grate Stoker."

C. B. Doolittle.
S. H. Barce.
F. D. Quinlan.

"Design of An Intake Manifold for Low Grade Fuels."

Harlan Bird.

"Shock Absorption of Automobile Tires."

L. S. Maranz
L. B. Newman.

"A Proposed Design of the Hydraulics Laboratory for The Greater Armour Institute of Technology."

Wm. A. Heitner.
John Plocar.

"The Relative Cost of Operating Steam and Electric Locomotives for Switching Purposes on the St. Paul R. R. Industry Tracks."

J. P. Sanger.
S. N. Havlick.

"A Proposed Design of an Experimental Automotive Laboratory for The Greater Armour Institute of Technology."

B. E. Wolgemuth.
W. S. Pawlowski.

"Test of a 300 pound De Laval Oil Purifier and Clarifier."

S. H. Webster.

"A Proposed Design of Steam Laboratory for The Greater Armour Institute of Technology."

J. H. Clouse.
F. C. Duennes.

"Thermostatic Temperature Control of Gas Engine Jacket Water."

M. G. Gross.
A. J. Steiner.

ALUMNI NOTES

EXECUTIVE COMMITTEE MEETING

A meeting of the Alumni Executive Committee was held on Jan. 11, in the grill room of the Great Northern Hotel. Those present were President Matthews, Lynn E. Davies, Roscoe Harris, Sidney Jones, W. Oberfelder, E. A. Freeman, and C. A. Knuepfer. The committee decided to hold a dance on Feb. 4, 1921, in the Red Room of the Hotel La Salle. All alumni, and the present Senior class are invited to attend. The regular fall Alumni Meeting and Banquet has been dispensed with, and the next meeting of this kind will be held in May, 1921.

*NEW ADDRESSES

Howard Cooper, '13, has left the Baltimore Copper Works and is now connected with the Sinclair Oil Refining Company in Chicago.

Donald E. Cable, '18, after obtaining his M. S. degree in Chemistry at Madison, Wisconsin, while employed there by the U. S. Forest Products Laboratory as chemist and engineer, has gone to the Agricultural Experiment Station of the University of Wyoming as assistant research chemist.

Ralph A. Walther, '09, formerly with the C. & N. W. Ry., is now superintendent of construction for the C. E. Carson Co., of Chicago.

John W. Tierney, '17, is with the Electric Storage Battery Co., Chicago, in their operating and construction department.

Paul Stern, '20, is chemist for the American Cocoanut Butter Co.

*Note.—Both the college and the Alumni Association are very anxious to keep an accurate record of all Alumni. The reader is therefore urged to help us by sending in any such information.

Ernst Sieck, '15, has left the American Coke and Chemical Co. to become chemical engineer for the Abbott Laboratories, Chicago.

Louis A. Simons, '11, is now Staff Engineer with L. V. Estes, Inc., Chicago.

Irwin Herbert Shram, '08, has been transferred from Susquehanna, Pa., to Marion, O., where he is Terminal Superintendent for the Erie Railway Co. He was formerly Division Engineer for the same road.

Louis Roller, '12, has returned to Chicago from Sioux City, Iowa, to act as Sales Engineer for the McClellan Refrigerating Company.

R. W. Regensburger, '20, is Testing Engineer for Swift & Co., at their Chicago yards.

Louis I. Potter, '99, is Valuation Pilot for the N. Y. C. R. R. at the New York Terminal.

Harold C. Peterson, '20, is another one of our recent graduates who has seen opportunities through the position of Engineer with Swift & Co., while William McCauley has chosen the Chemical Department of the same firm as his road to success.

Sidney Kahn, '12, has become Secretary of the National Vinegar Corporation, Colgate Creek, Md.

BOOK NOTES

Among the recent additions to the library, the following have been selected as of especial interest to the students in the departments of:

MECHANICAL ENGINEERING

Hoffman, J. D. *Handbook for Heating and Ventilating Engineers.*

A practical discussion, with tables and charts on design and installation. The book covers the fundamental principles of heating and ventilating and gives applications and designs in a manner that can be understood clearly.

Ivens, E. M. *Pumping by Compressed Air.*

This book contains the necessary information for the study, design, installation, and operation of a compressed air pumping plant of any size or capacity.

Moore, H. F. *Textbook of the Materials of Engineering.*

A concise, elementary presentation of the physical properties of the common materials used in structures and machines. Brief descriptions of their manufacture are also given.

Sterling, F. W. *Marine Engineers' Handbook.*

This handbook, which summarizes the best practice and most approved modern theory of marine engineering, is intended for designing and operating engineers.

ELECTRICAL ENGINEERING

Dawes, Chester L. *Direct Currents.*

A thorough discussion of the many types of machinery and transmission devices which are met in practice.

Lawrence, R. R. *Principles of Alternating Current Machinery.*

The book covers the principles underlying construction and operation. Only the most important types of machines are included, but these are developed in detail to bring out important principles.

RANKIN, ROBT. *Storage Battery Practice.*

A book designed for the practical engineer. The nature and action of primary and secondary cells are explained and there is a chapter devoted to manufacture. The directions for installation, operation, and repair are simple and to the point.

SLOANE, T. O. *Standard Electrical Dictionary.*

"All the recent advances in appliances, new developments and refinements in theory have been fully treated."

CIVIL ENGINEERING

FOWLER, C. E. *Ordinary Foundations.*

This new work gives the latest practices and methods in its field. It takes up the working details and shows the results of actual experience.

KNOWLES, MORRIS. *Industrial Housing.*

The problems of appropriate planning of streets, blocks and lots, parks and recreation facilities, drainage, sewerage, water supply, gas and electricity, transit and transportation, health and sanitation are all thoroughly discussed, as well as the actual planning and building of houses.

PAASWELL, G. *Retaining Walls, Their Design and Construction.*

The author considers the theory and design of retaining walls for earth, and the tools, machinery, concrete forms and work required in their construction.

SIMON, F. C. *Dredging Engineering.*

The construction and operation of the principal types of dredges are described in detail. The second half of the book deals with the actual planning and working out of dredging problems.

CHEMICAL ENGINEERING

DERR, LOUIS. *Photography for Students of Physics and Chemistry.*

This book on the general principles and processes of photography is intended for students who are interested in its scientific aspect.

MATTHEWS, J. M. *Application of Dyestuffs to Textiles, Paper, Leather and Other Materials.*

The book appeals to the interest of all those concerned in the application of dyestuffs. A brief discussion of the use of dyes in lines of industry other than the field of textiles is included.

MAXTED, E. B. *Catalytic Hydrogenation and Reduction.*

In his preface the author states that "the present volume has been written with the object of presenting in easily accessible form the numerous examples of catalytic hydrogenation.

SLOSSON, E. E. *Creative Chemistry.*

An interestingly written book for the general reader on the application of chemistry in the industries and the derived products. It contains chapters on explosives, fertilizers, artificial dyes, perfumes and essences, cellulose, rubber, sugar, corn products, vegetable oils and their products, poisonous gases in warfare, products of the electric furnace, and metals.

OF GENERAL INTEREST

BISHOP, J. B. *Theodore Roosevelt and His Time Shown in His Letters.*

This is the biography which was written with Roosevelt's cooperation and for which he contributed his correspondence. The result is a combined study of personality and a history of New York state and America from 1881 to 1919.

CHERINGTON, P. T. *Elements of Marketing.*

A description of the processes of distributing merchandise, including storing, transporting, selling and other concrete problems.

GOLDMAN, O. B. *Financial Engineering.*

In this book engineering methods are applied to the solution of business and administrative problems, teaching how to translate engineering factors into dollars and cents. All mathematical deductions are worked out in detail.

HINDUS, M. G. *Russian Peasant and the Revolution.*

"In order to fully understand the Russian revolution and its ultimate destiny," says the author, "we must understand the

Russian peasant, who constitutes by far the most important element, and the mightiest force in Russian life."

MARTIN, E. S. *Life of Joseph H. Choate as Gathered from His Letters.*

This story of a famous statesman in his own words gives a glimpse into the diplomatic life of the United States and Europe.

PURINTON, E. E. *Personal Efficiency in Business.*

Suggestions are here given in popular style for the cultivation of mental, physical and hygienic habits which will put one into the mood for deserving advancement in business.

TRENT, W. P., & WELLS, B. W. *Colonial Prose and Poetry.*

The object of the anthology is to give the critic of literature an opportunity "to study the effects of environment upon the literary powers and products of a transplanted race."

TUELL, H. E. *The Study of Nations.*

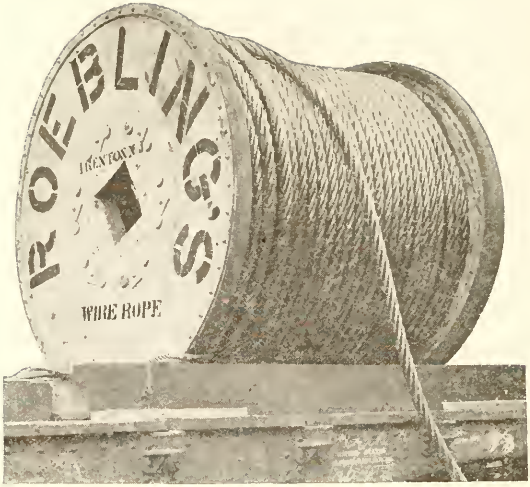
To aid international understanding the author emphasizes a tolerant and appreciative attitude toward nations other than our own. Each nation is studied from the point of view of its present individuality, of how history has made it what it is, and of what it may be expected to contribute to civilization.

Edith Ford, Associate Librarian.

HAVE YOU ONE?

One of the most comprehensive and valuable handbooks we have found is Waterman's Handbook of Mathematics for Engineers." This little book contains in condensed form, all of the important formulae of Algebra, Trigonometry, Analytical Geometry, Differential and Integral Calculus, Mechanics, Strength of Materials, and Hydraulics. There are also sections devoted to Heat Engineering and Electrical Engineering, a five place table of logarithms, five place tables of both the logarithmic and natural functions of angles, and a small steam table. This book can easily be slipped into the vest pocket and costs but $1.50. We would advise every engineer to have one.

ALPHABETICAL INDEX OF ADVERTISERS.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Sworn to and subscribed before me this 6th day of Januuary, 1921.

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Chicago, Jan. 6, 1921.
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CONTENTS.

What Is Air Pressure?

THE air is composed of molecules. They constantly bombard you from all sides. A thousand taps by a thousand knuckles will close a barn door. The taps as a whole constitute a push. So the constant bombardment of the air molecules constitutes a push. At sea-level the air molecules push against every square inch of you with a total pressure of nearly fifteen pounds.

Pressure, then, is merely a matter of bombarding molecules.

When you boil water you make its molecules fly off. The water molecules collide with the air molecules. It takes a higher temperature to boil water at sea-level than on Pike's Peak. Why? Because there are more bombarding molecules at sea-level—more pressure.

Take away all the air pressure and you have a perfect vacuum. A perfect vacuum has never been created. In the best vacuum obtainable there are still over two billion molecules of air per cubic centimeter, or about as many as there are people on the whole earth.

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This was research in pure science—research in what may be called the chemistry and physics of high vacua. It was undertaken to answer a question. It ended in the discovery of a method of filling lamp bulbs with an inert gas under pressure so that the filament would not evaporate so readily. Thus the efficient gas-filled lamp of today grew out of a purely scientific inquiry.

So, unforeseen, practical benefits often result when research is broadly applied.

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INVESTIGATION OF THE EFFECT OF AIR CONDITIONS UPON THE POWER OF AVIATION ENGINES

By Harold S. White, '17

I. AIR TEMPERATURE EFFECTS.

From the results of many engine tests it has been found that the indicated power is proportional to the weight of air taken by the engine. Assuming the same reaction of combustion, the power of an engine should be directly proportional to the weight of charge used. Changes in air temperature such as we are dealing with should not affect the reaction of combustion except as it affects air weight.

From the foregoing we get the relation:

$$HP = C \times W. \qquad (1)$$

We are considering the effect of air temperature alone, other factors such as throttle opening, speed, and air pressure being held constant.

The present day theory follows. If we consider the engine as a displacement pump the volume of air handled is constant because the displacement is constant.

The following symbols will be used throughout the paper:

HP = Horsepower.
W = Weight of air per sec.
C = Constant.
T = Absolute temperature.
D = Density of air in lb. per cu. ft.
V = Volume of air.
Vo = Specific volume of air in cu. ft. per lb.
u = Velocity of air.
P = Pressure of air.
P_1 = Pressure of air entering orifice.
P_2 = Pressure of air leaving orifice.
P_m = Mean pressure of air $(P_1 + P_2) \div 2$.
n = Exponent (1.405 for adiabatic expansion).
Ha = Head in ft. of air.

$$\text{Now } W = V \times D \qquad (2)$$

$$\text{or } W = C \times D \text{ (since } V = \text{c.)}$$

Therefore HP. = c × D. (From Eq. 1 and Eq. 2) (3)

From this we can see that horsepower is proportional to density.

$$\text{Now } Va = 53.34 \times \frac{T}{P} \text{ and } D = \frac{1}{Va}$$

$$\text{Then } D = c\,\frac{P}{T} \qquad (4)$$

$$\text{Therefore HP.} = c \times \frac{1}{T} \text{ (Since } P = c) \qquad (5)$$

This theory that power is proportional to density (Eq. 3) or inversely to the absolute temperature (Eq. 5) is commonly accepted by engineers of today, as is evidenced by such correction factors as the following, taken from the technical press:

"Horsepower Computations.—The horsepower values may be referred to standard conditions of 760 mm. barometric pressure and 15 deg. cent. by a correction factor. Humidity is not considered.

Where

Horsepower corrected = horsepower reading × C.

C = Correction factor.

$$C = \frac{29.92}{H} \times \frac{459 + T}{459 + 59}$$

H = Barometric pressure-in. of mercury.

T = Air temperature deg. fahr.

Also for the theoretical temperature correction alone we have given by the National Advisory Committee for Aeronautics Report No. 45, page 31, Plot 4.

$$F_o = \frac{273 + T}{273}$$

Where

F_o = Theoretical factor,

T = Temp. in deg. cent.

Both of these formulae show that theoretically the power is inversely proportional to absolute temperature.. From the last mentioned report we can also see the divergence of the actual

experimental corrections for the temperature from the theoretical values. This plot is shown in Fig. 1.

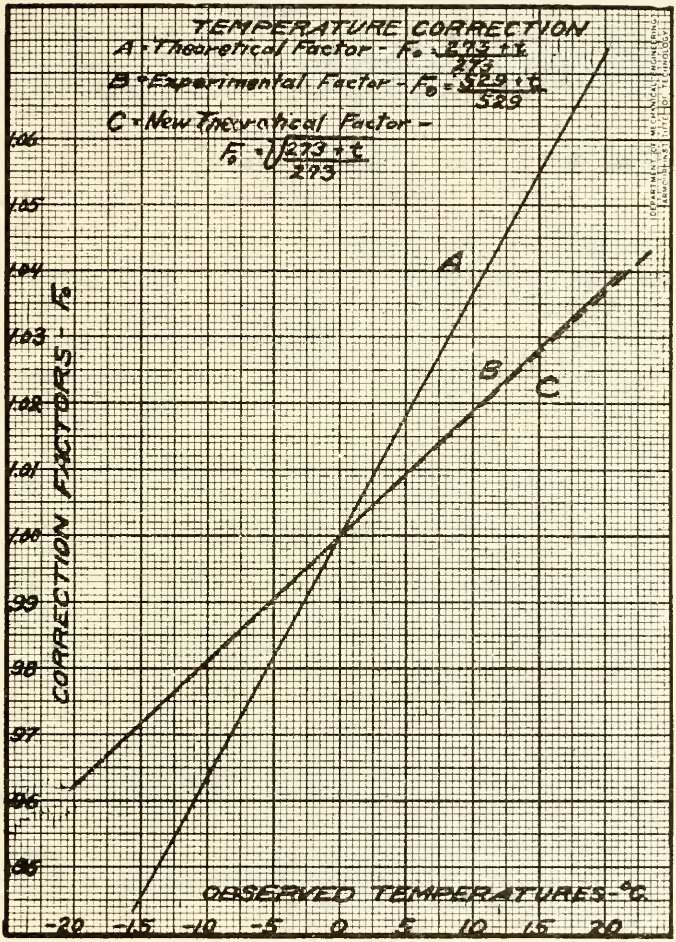


Fig. 1.

Showing the Close Agreement Between the New Theoretical Factor and the Experimental Factor.

In the above theory is the assumption that the volume is constant a correct one? The air flow through an engine is not a displacement proposition, but should be considered on a restricted flow basis. The valves have an orifice effect, and we shall investigate the air flow on this basis.

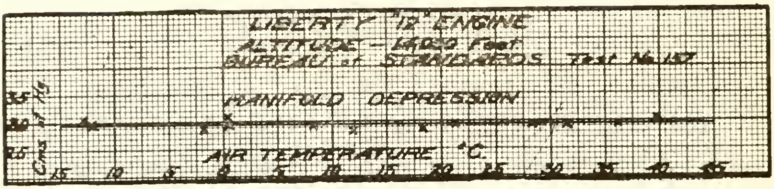


Fig. 2.
Showing the Constant Manifold Depression for Air Temperature Changes.

From "Lucke's Thermodynamics" (page 1098) we can derive an approximate formula for flow through an orifice with the following assumption: If the drop in pressure is small, the work derived from expansion may be neglected, and the fluid may be considered as non-expansive and of a density corresponding to the mean pressure on the two sides of the orifice and to the original temperature.

$$u = \sqrt{2g\,Ha} \qquad (6)$$

$$Ha = Va\,(P_2 - P_1) \qquad (7)$$

$$Va = 53.34 \times \frac{T}{P_m} \qquad (8)$$

Putting Equation 7 in terms of P_1, P_2 and T, we have

$$H_a = \frac{c \times T \times (P_2 - P_1)}{(P_2 + P_1)}$$

We can see from Fig. 2 that the manifold depression is constant for temperature changes, and therefore it is reasonable to assume that the pressure drop through the valves will also be constant. Therefore, let us assume that the pressures are constant.

Then:

$$Ha = c\,T \qquad (9)$$

$$u = \sqrt{2\,g\,c\,T}$$

$$= c\,\sqrt{T} \qquad (10)$$

$$V = u \times \text{area (which is constant)}$$

$$= c\,\sqrt{T} \qquad (11)$$

From this we see that the volume varies as the square root of the temperature instead of being constant, as is assumed in the present day theory.

For a more exact proof we have from "Goodenough's Thermodynamics" (page 252):

$$\frac{u^2}{2g} = \frac{n}{n-1}(P_1 V_1)\left[1 - \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}\right] \qquad (12)$$

Assuming only frictionless, adiabatic flow,

$$\text{or } u = \sqrt{2g\frac{n}{n-1}P_1 V_1\left[1 - \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}\right]} \qquad (13)$$

Now P. V. = R. T. and if the pressures are constant

$$u = c\sqrt{T}$$
$$\text{or } V = c\sqrt{T}$$

which is the same result as was obtained by an approximate method in Equation 11.

The fact that volume increases with temperature is shown by Fig. 2 of Mr. S. W. Sparrow's paper, given in the March, 1921, issue of the S. A. E. Journal.

Since the volume is not constant for temperature changes, horsepower cannot be proportional to density, as can be seen by following the reasoning in the present day theory. (Eq. 2 and Eq. 3).

If volume varies with the square root of the absolute temperature, let us see how weight of air and horsepower will vary.

$$\text{Now } W = V \times D$$
$$= c\sqrt{T} \times D \qquad (14)$$

$$\text{and } D = c \times \frac{1}{T} \text{ (for constant pressure).}$$

$$\text{Then } W = c\sqrt{T} \times c \times \frac{1}{T} \qquad (15)$$

$$W = c \times \frac{1}{\sqrt{T}} \qquad (16)$$

$$\text{Therefore H. P.} = c \times \frac{1}{\sqrt{T}} \qquad (17)$$

Equation 16 may also be derived from Equation 1188 of "Lucke's Thermodynamics" (page 1098) by assuming the pressures to be constant and substituting

$$\frac{R\ T_1}{P_1} \text{ for } V_1$$

From Lucke (Eq. 1188):

$$W = \sqrt{2g \frac{n}{n-1} \frac{P_1}{V_1} \left[\left(\frac{P_2}{P_1} \right)^{\frac{2}{n}} - \left(\frac{P_2}{P_1} \right)^{\frac{n+1}{n}} \right]}$$

we get:

$$W = c \times \frac{1}{\sqrt{T}}$$

Durley (A. S. M. E. Translations '06, page 206) checked experimentally the effect of air temperature upon air flow through an orifice under constant head, and found that it varied inversely as the square root of the absolute temperature.

The correction factors derived from the relation

$$H.\ P. = c \times \frac{1}{\sqrt{T}}$$

are shown in Fig. 1. It will be seen that the new correction comes very close to the one derived from experimental data. Table 1 also shows the agreement between these factors. It may be seen from the N. A. C. A. report (page 22, plat 7) that their last check tests are closer to the new relation than to their earlier correction factor.

Having seen how cloesly the new relation fits the test results it is reasonable to consider that the assumption of constant pressure drop may be correct, especially in view of the constancy of such pressure drops as we can observe.

II. AIR PRESSURE EFFECTS.

Continuing our investigation on an orifice flow basis, let us see how pressure changes affect the flow for constant temperature. From the N. A. C. A. Report No. 48, page 7, shown in Fig. 3, we see that the manifold drop in pressure is proportional to the

air pressure. Therefore, it is reasonable to assume that the drop through the valve would be proportional to the air pressure. That is, the ratio of the two pressures is constant,

$$\text{or } \frac{P_2}{P_1} = c.$$

$$\text{Also } \frac{R_1 T_1}{P_1} = V_1$$

Using these two relations in connection with equation 12, we see that

$$u = c.$$

$$\text{Therefore } V = c.$$

$$W = V \times D.$$

$$\text{Therefore } W = c \times D.$$

$$H\ P = c \times W = c \times D.$$

$$\text{Now } D = c \times P \text{ (for constant temperature).}$$

$$\text{Therefore } HP = c \times P.$$

This same result can be obtained from the approximate formula previously used or from Lucke's Equation 1188. The fact that the horsepower is proportional to pressure has been shown many times. Therefore, the assumption that the pressures maintain a constant ratio seems to be justified. From this we may see that the new theory is in agreement with actual results for pressure changes also. In this analysis we see that the volume of air is constant, and that therefore the power is proportional to density. In the temperature analysis the volume was not constant, and therefore the power was not proportional to the density. That is, power is proportional to density for pressure changes only.

III. AGREEMENT OF NEW THEORY WTH TEST RESULTS.

After observing how closely the new horsepower temperature relation checked the N. A. C. A. correction factor secured from the Hispano-Suiza engine tests at various altitudes and with various carburetors, the author plotted the square root relation on their best check test (No. 119) and found all points except one within ½ of 1% of this curve. This relation has also been applied to Liberty engine tests at 14,000 ft. and at 25,000 ft., and it has been found to express the slope of the points very well.

While this paper was written with the idea of investigating the air temperature effect on aviation engnes only, there is nothing in the reasoning which does not apply to any internal combustion engine of this type. The author therefore applied the new relationship to some of the published tests on other engines.

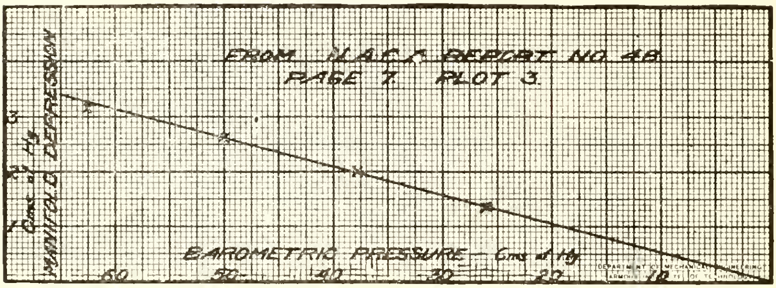


Fig. 3.
Showing the Relation Between Manifold Depression and Barometric Pressure.

By applying it to Prof. O. C. Berry's tests, conducted at Purdue University, on an automobile engine at one-half throttle and 1,000 R. P. M., it was found that the average of the points for mixture ratios of .1 lb. fuel to 1 lb. air, .09 to 1, and .08 to 1, were within 2% of the square root relation for temperatures from 80 deg. fahr. to 275 deg. fahr. Prof. Berry's paper was given at the Spring meeting of the A. S. M. E., June 16, 1919.

investigation was also made of some tests on a tractor engine made by the International Harvester Co. and reported in the S. A. E. Journal for February, 1920. These tests were made at wide open throttle, at speeds from 300 rpm. to 1,000 rpm., and at various mixture ratios.

It was found that by averaging the results of Table II of this report, that the average decrease in B. H. P. from 70 deg. fahr. to 240 deg. fahr. was 12.54%. The decrease that would be obtained from the square root relation is 12.22% and that obtained from a density of air basis (inversely as the absolute temperature) would be 22.98%, using the same temperatures as given in the table. This shows the close agreement between the new relation and actual results as compared with the density relation. Plotting power against temperature for several mixture ratios and speeds showed again that the square root relationship expresses the average slopes of the points very well.

IV. APPLICATONS.

The author fully realizes that there are a great many factors, such as distribution, stratificaton, mixture ratos, volatility of fuel, vapor pressure, etc., that may influence this relationship between power and air temperature, but where the conditions are such that these do not vary too greatly, the orifice flow of the charge is the governing factor.

In resume it will be seen that we have applied this relation to various engines, altitudes, throttle openings, and speeds, and consequently it appears to be applicable to the gasoline engine in general.

Having observed that on a basis of orifice flow the horsepower should vary inversely as the square root of the absolute temperature, and directly as the pressure, the author suggests that the following formula be adopted for converting horsepower to standard conditions:

$$HP_{\text{Stand.}} = \frac{\text{P stand.}}{\text{P actual}} \times \sqrt{\frac{\text{T actual}}{\text{T stand.}}} \times \text{HP. actual}$$

The range of pressures and temperatures over which this correction may be applied is necessarily limited, but for ordinary atmospheric condition the relation should hold. By using a relation between altitude (pressure) and temperature, the effect of the former upon power can be determined. All problems of the gasoline engine having to do with the air flow should be investigated on a basis of orifice flow.

The author wishes to acknowledge the assistance given him by the Bureau of Standards. An investigation along this line was suggested to him by Mr. Stanwood A. Sparrow, of the Bureau staff.

TABLE NO. I.

HORSEPOWER CORRECTION FACTORS FOR TEMPERATURE.

Centigrate Temperatures Standard Temperature = 0° C.			Fahrenheit Temperatures Standard Temperature = 60° F.		
Temperature 0° C.	Correction Factor from N. A. C. A. No. 45	Proposed Correction Factor	Temperature 0° F.	Correction Factor from N. A. C. A. No. 45	Proposed Correction Factor
—20	.9622	.9620	—40	.8980	.8980
—10	.9811	.9810	—20	.9183	.9200
0	1.0000	1.0000	0	.9387	.9400
10	1.0189	1.0188	20	.9590	.9600
20	1.0378	1.0364	40	.9800	.9800
30	1.0567	1.1535	60	1.0000	1.0000
40	1.0756	1.0715	80	1.0210	1.0193
50	1.0944	1.0882	100	1.0410	1.0382
60	1.1135	1.0964	120	1.0610	1.0574
70	1.1324	1.1215	140	1.0815	1.0748
80	1.1512	1.1375	160	1.1020	1.0925
90	1.1702	1.1538	180	1.1225	1.1100
100	1.1891	1.1695	200	1.1430	1.1270
110	1.2080	1.1850	220	1.1635	1.1445
Multiply by factor to get power at 0° C.			Multiply by factor to get power at 60° F.		

A NEW SYSTEM OF DIRECT MOTOR CONTROL

By Henry I. Rosenthal '10.

The following article describes the system of motor control invented by Leigh J. Stephenson, and is a reconstruction of a paper written in conjunction with him. The tests recorded by the curves were conducted by Mr. Stephenson.

At the present time there are three general types of motors serving the field covered by direct current power, and while these three types are in general more satisfactory and possess a greater adaptability than the motors serving the alternating current field, still with the present method of control used with these three general types there is much wanting in the inherent characteristics obtained with them.

These three types of motors are the shunt, the series and the compound, and while each possesses many desirable characteristics, there are points found in one type which are entirely lacking in another type, which points would be desirable in all.

The shunt motor has a fairly constant speed, which may be adjusted as desired. It is not particularly susceptible to changes in voltage and may be used to regenerate power. It, however, does not possess high starting torque except with excessive currents and is not adaptable where rapid acceleration is desired. The series motor while possessing the ability to develop a high torque without excessive currents and ability to accelerate rapidly has but one efficient operating speed and is unsuited to applications where it is desirable to regenerate power. The speed of the series motor is variable depending on the superimposed load and applied voltage, this characteristic in many cases being undesirable.

The compound motor while possessing all of the desirable features of the shunt and series motor in a greater or less degree is, nevertheless, a compromise and the advantageous characteristic of the shunt and series motor are obtained only partially by the use of this type of motor.

The system of control, invented by Leigh J. Stephenson of 1315 Monadnock Block, Chicago, Illinois, and described in this paper, gives to the motor the full advantages of the type now generally used for any particular service while still mantaining the advantageous characteristic not possessed by that type.

The system of control described in this paper provides means of giving the motor a high torque at starting and rapid acceleration, with the characteristics of the series, shunt or compound motor, as desired on running. At the same time it provides for regeneration of power when it is desired to slow down the motor, thus providing a source of power having all the desirable characteristics now obtained in present motor application, and the additional desirable characteristics which heretofore have been impossible to obtain. In addition to giving the motor the above desirable characteristics, the system is so designed that it provides means whereby the characteristics may be changed while the motor is operating, at the will of the operator, thus providing a source of power having characteristics adapting it to the peculiar requirements of any mechanism. It also provides a system of control by which a single type of motor may be given the characteristics of a shunt, series or compound motor as desired, thereby minimizing the variations in design.

There have been many attempts by many inventors to devise systems of control possessing the characteristics of the system described in this paper. These attempts have been divided into two classes—the first, that of using a motor with a separately excited field has met with success but has led to such complications as to make its use unsuited for general application. The second method, that of using a counter electro-motive force has been previously unsuccessful due to unstable conditions obtained within the operating range of the motor. The method of control described in this paper, while belonging in this latter class, does not possess the undesirable feature of instability, and it will be clearly shown later in this paper that this method possesses a degree of stability as great as now obtained with the standard shunt motor.

The accompanying sketch marked Fig. 1 illustrates the general connections necessary for this method of control. The motor used is of the shunt type and the shunt field winding is connected in series with the armature which for purposes of convenience, will be termed a regulating dynamo. This motor field winding and regulating dynamo armature in series form the field winding circuit which is connected directly across the line. The armature of the regulating dynamo is connected mechanically to the motor armature so that the speed of the regu-

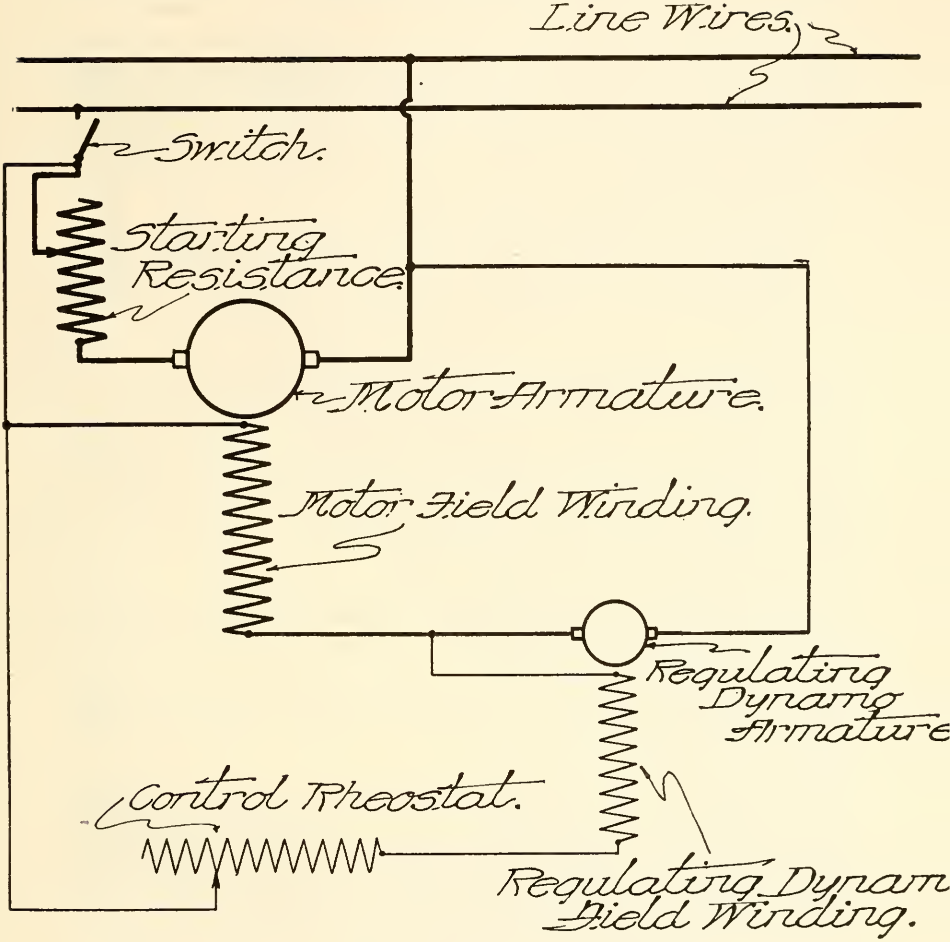


Fig. 1

lating dynamo is dependent upon the speed of the motor. The regulating dynamo is provided with a field winding, which is so connected that the electro-motive force of the regulating dynamo opposes the line voltage impressed upon the field winding circuit of the motor. This field winding of the regulating dynamo is connected in series with a control rheostat, which circuit is connected directly across the field of the motor, so that the current in the regulating dynamo field circuit will al-

ways be proportional to the current in the motor field winding. The ratio of these currents may be varied by adjusting the control rheostat connected in series with the regulating dynamo field.

The performance of a motor thus equipped may be divided generally under three divisions:

Performance under acceleration.

Performance under changes of load with constant voltage.

Performance with constant torque and changes in applied voltage.

A motor equipped as described, on starting from rest and accelerating to the running speed of the motor will perform as a series motor, the current in the field being proportional to the current in the armature during the acceleration period, thus obtaining the desirable characteristics of the series motor, namely, the relatively small armature current to obtain a required torque, and a minimum period of acceleration.

When subject to load changes, with a constant applied voltage, the performance of a motor equipped with this control will depend upon the speed ratio between the motor and the dynamo, upon the inherent tendency of the motor to change speed with change in load, and to a slight extent upon the relative saturation of the motor and dynamo fields.

By proper choice of speed ratio the motor can be given its natural inherent characteristics. If for any reason it were desired to have the speed of the motor vary, when subjected to load changes, to a greater extent than it would naturally vary, this could be accomplished by decreasing the speed of the dynamo relative to the speed of the motor. With a few series turns on the motor field it is possible to approximate series speed characteristics while running.

Broadly, therefore, a shunt motor with this control could be given startling characteristics closely approximating that of a series motor, and by the methods outlined above the speed characteristics while running could be modified to approximate either the shunt, the series, or intermediate points.

Figure 3 shows a set of characteristic curves which were plotted from a test of an outfit equipped with the control described in this paper. These tests were conducted with constant applied voltage. The lines marked A, B, C, D. and E represent various speed ratios between the motor and the regulating dynamo.

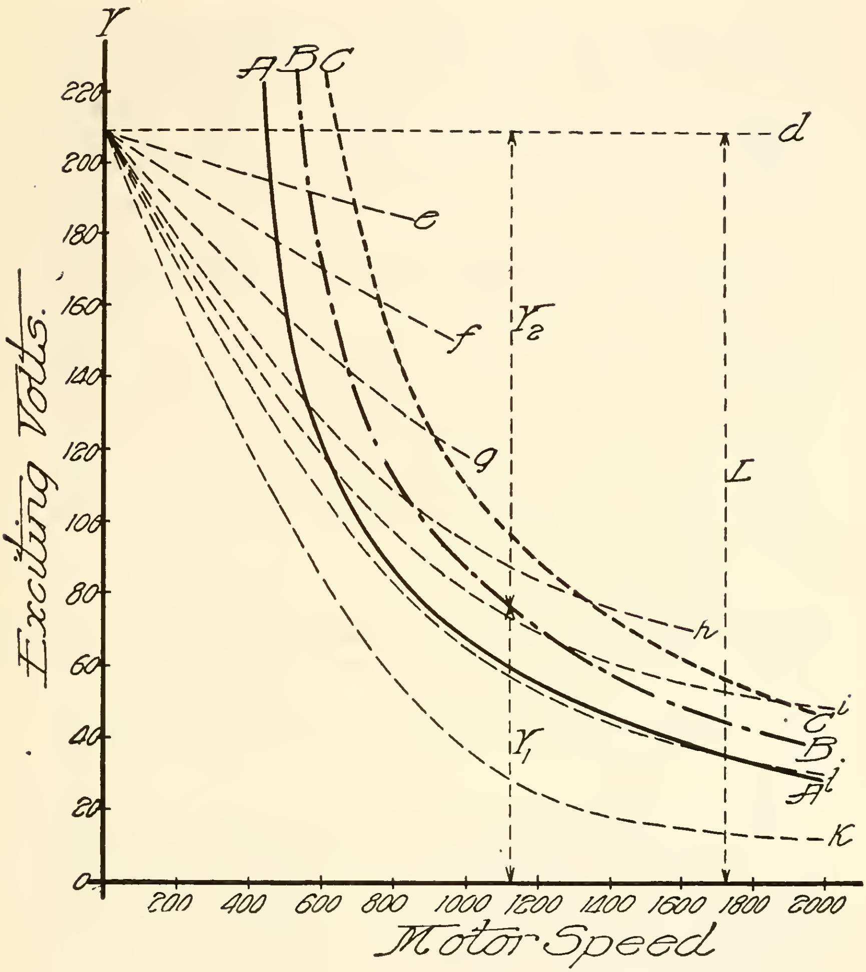


Fig. 2

When operating under constant torque and with changes in applied voltage, the performance, if the motor were operating at a constant low point in its speed range, would approximate the performance of a series motor, its speed increasing with an increase in voltage and decreasing with a decrease in voltage. An adjustable speed shunt motor under the same conditions would have the same characteristics inasmuch as its field would be so saturated as to not readily respond to voltage changes.

When operating on a high point in its speed range the performance under changes in applied voltage would depend upon the original design of the individual equipment. With the magnetic saturation of the dynamo field relatively low as compared to the magnetic saturation of the motor field, the changes in speed with changes in voltage would be similar to that obtained when the motor is operating at a low point on its speed range and where there is always a relatively low saturation of the dynamo field as compared with the motor field. If the saturation of the dynamo field at high speeds is relatively high as compared with the saturation of the motor field, the condition just opposite of that described will result, namely, the speed of the motor will decrease with an increase in voltage and will increase with a decrease in voltage. At some intermediate point the motor speed will remain constant with changes in applied voltage. This intermediate point is not necessarily the point where the saturations of the two fields are equal.

The design of the control permits of material variation in the relative saturation of the motor and dynamo field at the higher speeds, and therefore considerable latitude in the characteristics of the motor under changes in voltage as described above without materially affecting the performance of the motor under changes in load.

With this system of control, on starting, resistance is placed in series with the motor armature, thus limiting the initial inrush of current in the same manner as in the methods of control now commonly in use. As the apparatus is at rest, the regulating dynamo will not generate any counter-electromotive force, so that that field of the motor will take maximum current and consequently the motor will develop maximum torque. As the motor accelerates, the regulating dynamo will generate an increasing counter-electromotive force, the value of which will depend upon the speed ratio between the motor and the dynamo, and also upon the amount of resistance in series with the field of the regulating dynamo. This will weaken the field of the motor as the generated voltage of the regulating dynamo increases. As the motor speed increases the motor armature current decreases and the ratio between the motor armature current and the field current remains approximately constant until the motor reaches the stable running speed corresponding to the setting of the adjustable field

resistance. This gives the motor the same accelerating characteristic as that of a series motor in which the ratio of these two currents is unity. The starting resistance in series with the motor armature can be cut out at a rate to keep the starting current within the desired limit, as is usual with the methods of control now commonly in use.

The rate of acceleration of the motor can be controlled by the rate at which the dynamo field resistance is cut out. The highest possible rate of acceleration is attained when the field resistance is all cut out in one step. The motor armature in this case is limited to a definite value fixed in the design of the control system, and can be held within the overload capacity of the motor.

For each setting of the adjustable field resistance there is a definite stable running speed for the motor for any particular load. With the dynamo field circuit open, the generated voltage of the dynamo is practically zero and the motor will run at its lowest normal running speed for full field. With all of the field resistance cut out of the dynamo field circuit the dynamo-generated voltage will be a maximum and the motor will run at its highest normal running speed for a weak field. Any intermediate speeds are obtained by adjusting this resistance.

Whenever it is desired to decrease the speed of the motor it is necessary to merely cut resistance into the field circuit, thereby decreasing its potential applied to the field winding of the motor. This correspondingly increases the generated voltage of the motor, causing it to rise above the line voltage, and in this manner to return power to the line.

The rate at which the motor is retarded can be controlled as desired by the rate at which the resistance is inserted in the field winding circuit of the regulating dynamo. If the motor is connected to any apparatus which at times tends to run above the speed desired, as a crane lowering a load, or a train descending a grade, the speed may be held at any desired point within the limits of the motor by merely adjusting the field resistance. This will be accomplished with a return of power to the line.

As mentioned above, for each setting of the field rheostat there is, at any given load, a definite stable speed for the motor. This will be brought out more clearly by a study of the curves shown in Fig. 2.

In this figure the curves, A, B and C show the change in speed of the motor with a change in voltage applied to the terminal of

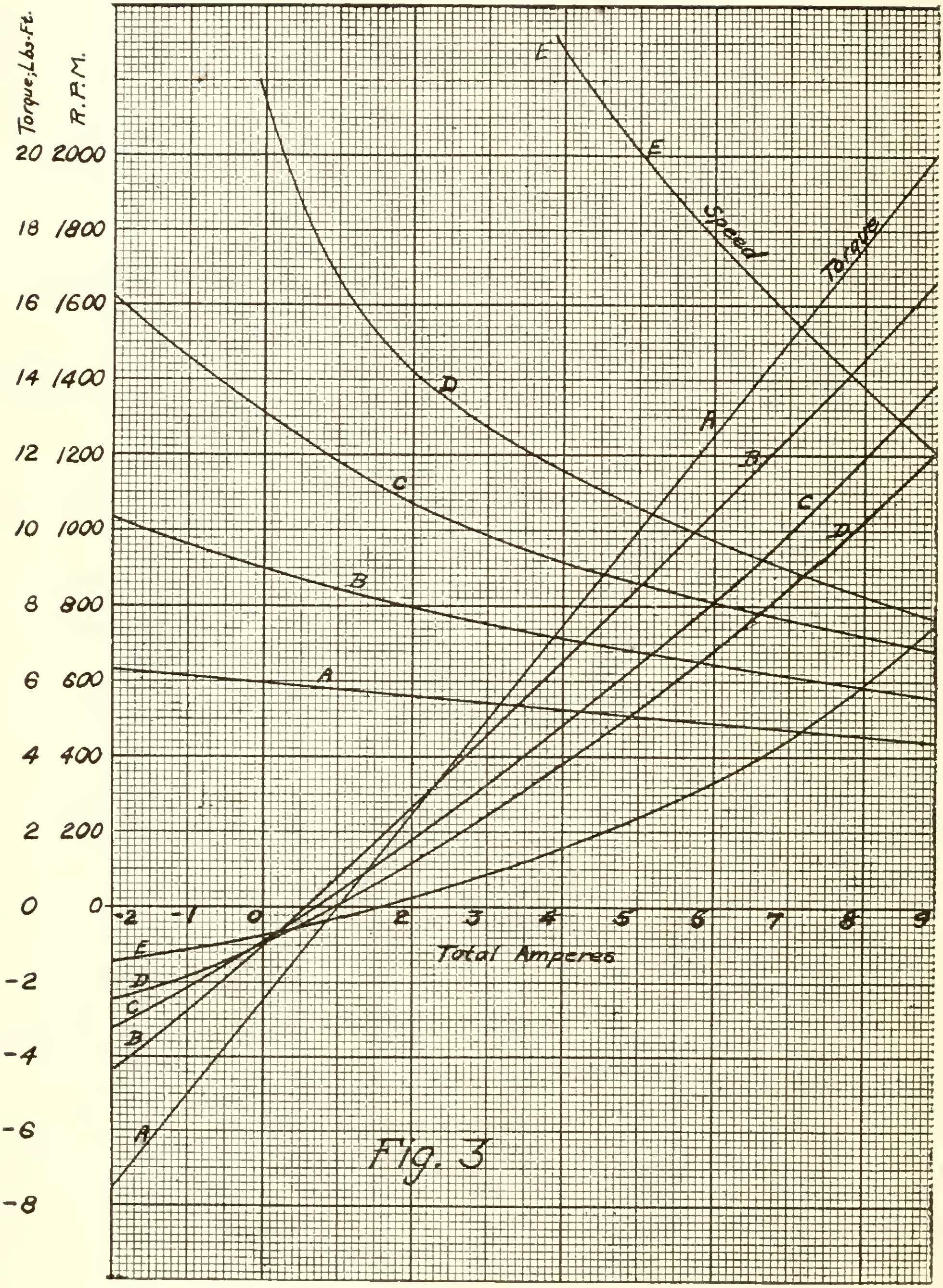

Torque; Lbs-Ft.
R.P.M.
20 2000
18 1800
16 1600
14 1400
12 1200
10 1000
8 800
6 600
4 400
2 200
0 0
-2
-4
-6
-8
-2 -1 0 1 2 3 4 5 6 7 8 9
Total Amperes
Speed
Torque
A
B
C
D
E

Fig. 3

the motor field winding. Curve B shows the changes in speed with zero armature current. Curve A represents the speed of the motor while carrying full load current with different potentials applied to its field terminals, and curve C indicates the speed of the motor at full-load breaking current. These curves are typical for any motor, irrespective of its control.

Lines d to k, inclusive, correspond to different settings of the regulating dynamo field rheostat and serve to indicate two things. namely, the voltages generated by the regulating dynamo, and the voltages applied to the field terminals of the motor. The distance between the line Y-d and the line O-X is a measure of the voltage across the motor field terminals when the field circuit of the dynamo field is opened. Upon this condition the voltage applied to the motor field is practically equal to full line voltage. The distance between the intersections of the curves A, B and C and the line Y-e and the anxis O-x are measures of the voltages applied to the motor field terminals, and the distances between the intersections and the line Y-d are measures of the voltages generated by the regulating dynamo for the same setting of the rheostat. In a similar manner the distances between the intersections of the remaining lines e to k, inclusive, and the lines A, B and C and the lines O-x and Y-d are measures of the voltages applied to the motor field terminals and the voltages generated by the regulating dynamo. The lines d to k, inclusive, correspond to settings of the rheostat which give equal increments of ampere turns in the regulating dynamo field winding.

For each setting of the field rheostat the motor speed is indicated by the intersection of the dynamo line for that setting with the motor line for the particular current which the motor is drawing.

For any setting of the field rheostat with changes in load the motor speed will follow along the dynamo line corresponding to this setting. The new speed will then be indicated by the intersection of this same dynamo line with the motor curve corresponding to the new current. It will be seen from this that the speed change with change of load is influenced by the spacing of the lines A, B and C, and the curvature of the dynamo lines.

The more nearly the dynamo lines are parallel to the motor lines the greater will be the change in speed with change of load. The dynamo lines cannot be straight lines, but must curve and be

asymptotic to the line O-X on account of the parallel connection of the dynamo and motor fields. The curvature of these lines depends on the speed ratio between the two machines and on the number of dynamo armature conductors.

Increasing the dynamo speed relative to the motor speed, or, in other words, increasing the speed ratio gives these dynamo lines a greater curvature tending toward a sharp bend, thus giving the motor a speed current characteristic approaching that of the shunt motor. Decreasing the speed ratio has the opposite effect and gives the motor a characteristic approaching that of the series motor.

The spacing of the lines A, B and C depends on the inherent tendency of the motor to change its speed with changes of load independent of the type of control. This is determined by the motor armature resistance and the changes of magnetizing force with changes of load. This latter is influenced by armature reaction and may be further affected by the addition of series field turns.

It will be noted that the speed load characteristics of the motor can readily be made as desired by the proper relation of the above factors.

It will be seen that the dynamo lines, on account of their curvature, intersect any one motor line but once, indicating but one speed for a given load and a given setting of the rheostat. This means that the motor is stable under all conditions. This is a distinctive feature of this system of control and one not to be found in previous systems of control using a counter-electro-motive force in the field circuit.

As mentioned above, the spacing of the motor lines, A, B and C is influenced by the addition of a few turns to the motor field winding. Another effect of these turns is to damp out current fluctuations during regeneration and to cause an equal distribution of load between motors operating in parallel on the same mechanism.

Compared to standard series motor control this system will eliminate a large part of the rheostatic losses during acceleration because resistance is used only to bring the motor up to its lowest running speed. When speed adjustment is required this system is particularly efficient because for all speeds above the lowest running speed no armature resistance is required.

In comparison with shunt motor control the field rheostat losses are largely eliminated because the regulating dynamo always functions as a motor, helping to carry the load.

Irrespective of the type of control that this system replaces, and aside from the saving due to regenerative braking, this system will show a higher efficiency than any of the present systems, for the reasons stated above.

Inasmuch as the many advantages of this system of control are obtained without the addition of complicated apparatus and as the general construction is similar to that of systems not having many of these features, its reliability will be equal to that of any present system.

As this system of control gives rapid acceleration and regenerative breaking, it is especially adaptable to any machine requiring frequent starting and stopping. This, in conjunction with the fact that load characteristics similar to those of a shunt, compound or series motor can be obtained, as desired, and with the fact that the speed can be adjusted to any desired value, makes this system of control especially suited as motive power for city and interurban railways, heavy traction, hoists and elevators, cranes, steel mill main rolls, planers, positive starting, printing presses, and many other applications. Its application to traction is more fully described herein.

For traction work the apparatus and wiring connections are the same as have been described. The motors may be operated either permanently in series or permanently in parallel, or where wide speed ranges are required series-parallel grouping may be used. The system is applicable either both for hand type drum controllers or for remote control, either for single or multiple units.

The characteristics of this system of control make it especially applicable to traction work, as it combines high starting torque, rapid acceleration, regenerative braking, adjustable running speeds, and choice of load characteristics.

Having a choice of load characteristics, it is possible to have the many advantages of a constant-speed motor while retaining starting torque and rapid acceleration.

On starting, resistance must be placed in series with the motor armature. This resistance can be cut out when the minimum speed of the motor is reached. Where series-parallel groupings are used no resistance is necessary at the transition point, as the

motors can be brought to proper voltage by field control to obtain smooth transition.

For the maximum rate of acceleration above the minimum running speed the field resistance can be cut out in one step and the current can be limited to a safe maximum by the design of the system. The field strength depending on the speed of the dynamo, it cannot be weakened beyond a predetermined value of each speed. For rates of acceleration less than the maximum the field resistance can be cut out step by step. As these steps will be very small, acceleration will be smooth and even.

It has already been explained that by cutting resistance into the dynamo field circuit regeneration is accomplished. By this means it is possible not only to hold a car or train on a down grade at any desired speed within the capacity of the motors, but also to gradually decrease the sped to the minimum running speed of the motors. The rate of braking depends upon the rapidity at which the resistance sections are cut in. The operator therefore has the rate of braking entirely under the control and will be guided in braking in the manner as is now customary with air brakes.

Operation of the system is extremely simple, as a single lever can control the starting, acceleration, speed setting and braking.

The motors while running will maintain their generated voltage even during an interruption of the supply voltage. This eliminates the possibility of flashovers at section breaks. This also provides a means of emergency braking on long down grades because the traction motors will thus furnish power for the air compressor motor independent of the main source of power supply.

The efficiency of this system of control is very high because of the large reduction in rheostatic losses, the fact that all points on the controller are running points, and because a large part of the energy required to accelerate a car or train is returned to the line through regenerative braking. The percentage of energy saved though regeneration will depend on the operating characteristics of the railway system on which it is used. It will be greater in hilly and mountainous regions than in level country. The amount will depend on the grades, the number of stops to a mile, the schedule speed, etc. Considering each car as a moving substation, at times putting power into the line, the voltage of the

line will be stabilized and the copper losses in trolley wire and feeder cables reduced because there will be less energy transmitted from the generating or substation for the same service.

It may be seen from the foregoing that the system of control described herein is applicable to any direct current installation, and is especially advantageous where high starting torque and rapid acceleration are necessary, and where regenerative breaking, adjustable speed or constant speed would be desirable.

STEAM TURBINE LOCOMOTIVE

According to the "Railway Gazette" of London, a turbine-driven locomotive is now being tried on the Swiss Federal Railways. It is converted from a standard 4-6-0 type as used on the Federal Railway. The turbine is reversible and is placed in front of the smokebox, power being transmitted by 30 to 1 gearing to a horizontal crank shaft placed above the leading truck, the rods of the six coupled wheels being extended forward and connected with the crankpin at each end of the crankshaft.

The engine is designed for a turbine speed of 8000 r. p. m. giving running speed of 49 miles per hour. The boiler is equipped with a superheater and a condenser is fitted below it, utilizing water from the tender to which later it is returned for cooling by being allowed to fall in narrow streams from the roof extending over the tender, which is designed for the purpose. As there is no blast nozzle an air draft through ventilators is used for maintaining the required action on the fire in conjunction with a blower. It is claimed that while making the trial trips the engine has shown a fuel economy of 25 per cent under that of the compound locomotive in service, while it runs very smoothly at high speeds, this being accounted for by the reduction of the reciprocating parts.

—"Mechanical Engineering," March, 1921.

COSTS AND THE ENGINEER

By Guy F. Wetzel, '15.

Of all the fields of activity open to the engineer, that of industrial administration and operation offer at least as attractive work and opportunity as any. However, the engineer can not use his purely technical training and knowledge as much as in the pursuit of engineering work, and must augment his technical knowledge by further study and practical experience. This is the case with any line of work, however, if he wishes to succeed.

In our modern industrial organization as a whole, the technical engineer very often comes in contact with problems, more or less of an accounting nature, especially in estimating cost, figuring actual cost, making reports and recommendations, classifying property accounts and so on. As the engineer enters the field of management, costs and cost reports, operating statements and balance sheets immediately become important to him, and he must at least have a working acquaintance with them.

The subject of costs is a very broad one, covering as it does, work from recording the payroll to the submission of the auditor's report. The word "costs" is used here to cover two general purposes; to determine costs for pricing purposes, and to record the results of operating a manufacturing business, in other words, both detailed cost of product, and general cost of manufacture and determination of manufacturing profits.

The work of the efficiency engineer, the production engineer, or the industrial engineer is very liable to include such problems as proper distribution of factory overhead expense, standardization of labor costs for cost estimates, stores control, analysis of operating statements, and balance sheets, analyzing or revaluing plant accounts, and making reports on factories from the financial as well as the operating view point.

Volumes could be written about any of these subjects so that this discussion must be brief and will be confined to costs and overhead expense analysis.

Manufacturing Costs are made up of three parts, each of which is independent of the other, and is made up of details that naturally come into their proper group. Two of these parts, labor and material, might be said to be definite and comparatively easy of

determination, while the third, variously referred to as overhead expense, factory overhead, burden, or indirect expense, is a variable and no method has yet been devised which will give as determinate results as can be obtained with the labor and material items. This statement applied both to the total manufacturing burden and the amount charged to any item of the product to absorb the burden. The total burden is made up of definite charges such as indirect labor, power, light, heat, maintenance and expense supplies, and variable or arbitrary figures, such as depreciation, building charge, reserve for taxes, and any other items which are determined by some one's decision rather than actual payments of invoices or bills. The total of all the figures for both definite and assumed items is determined, however, and the result used as a definite and correct figure in determining costs, and profits or losses. This accounts for the fact that sometimes plants which have made money show net losses, and others which have actually lost money can be made to show profits.

With the total burden for the plant settled, the next step is to make provision for allocating or proportioning it to the products manufacturing so that the selling price will include the cost of labor, cost of material, cost of burden, cost of selling, and profit. The methods for allocating the burden to the product are all arbitrary in at least some particulars, though some are more accurate than others, and each method will give different results as far as cost are concerned. This means that two factories producing the same kind of goods, operating under identical conditions, with equal finances, equally capable managements and workmen, and using the same percentage of profit, will figure different selling prices for the same article if they use different methods of distributing their burden.

As previously stated, there is no relation between material, labor and burden, but of the methods used for taking care of the latter factor, several arbitrarily assume a relationship and make burden a function of the labor charge, the material charge, or their sum.

These methods are:

(1) Percentage of direct labor added to direct labor charge plus material charge.

(2) Percentage of material charge added to the sum of matetrial and labor charges,

(3) Percentage of material plus direct labor added to their sum.

(4) Percentage of material to cover both burden and direct labor, added to material cost.

(5) Charge (in dollars) per labor hour, determined by dividing total department burden by the number of department direct man hours or total factory burden by factory direct man hours.

factory or department overhead by factory or department production, respectively.

(7) Machine hour rate.

(8) Process hour rate.

There may be other methods in use, variations from, or combinations of the above, but those mentioned include all the generally used plans.

The method to be used depends entirely on the nature of the product, the number of different products made in one plant, and the refinement of method considered desirable by the management. Another consideration is the ratio of burden to total factory cost, which indicates the relatve importance of accuracy in the burden distribution.

The percentage of direct labor (1) is one of the more common plans, which applies to a great many plants where simplicity is an important factor, and where the burden is not much greater than the direct labor. If the burden percentage is high (over 200%), compared with direct labor, any error in the labor figure is largely increased in figuring the burden. When some of the products acquire high priced labor and some cheap labor, it is obvious that the former will carry a higher burden charge even though less equipment and supervision are required.

Percentage of material charge (2) is suitable for an industry such as cement making, etc., where labor is a small item, and only one or two products are made.

Percentage of material plus labor (3), is not as accurate as (1), but it is usually used in the harness and saddlery industry. Using material as well as labor for a distributing basis, simply brings one more unrelated factor into the burden calculations.

Percentage of material (4), to cover both labor and burden gives very crude results if applied to a variety of products, but would apply in the same way as (2).

Charge per labor hour (5) is a more rational method than

any of those previously mentioned, and if classified, as for example, for bench and light machine work, medium sized machine work and heavy or specially expensive machine work, gives results comparable with the best, and with a small amount of work. This plan is very good for metal working plants, and also fits well into a number of other industries.

Charge per unit of production (6) is only adapted where one line of product is turned out, such as cement, brick, linoleum, etc., and a charge per ton, per thousand, per yard, etc., can be easily found to cover burden, or burden plus labor.

The machine hour rate method (7) and the process hour rate (8) are the highest developments in the problem of distributing overhead expense, which is of course, the most difficult part of cost finding and cost accounting. They are worked out in much the same way by charging all expenses for light, power, rent, depreciation, maintenance, supplies, etc., direct to a machine (7) or to a group of machines used in a process (8) and prorating factory administration, clerical work, miscellaneous expense, etc., to them on the basis of size, value or other factor. To get this plan worked out means a complete survey of the factory, prorating the power, rent, maintenance, supplies, etc., by measurement or estimate, charging depreciation direct, supplies direct, and other factory charges, including factory service and administration, based on floor space occupied, value, man hours, or a composite factor of all three. The result is a money charge per hour against all the work turned out in an hour by a machine or process group. To illustrate, if a planer finishes 30 pieces per hour and the machine rate is $.60 per hour, the burden cost of each is $.02.

In many cases it is desirable to get the overhead charges in terms of production rather than time. This can easily be worked out from the time charges by dividing by production per period, which gives a money charge per unit of production to cover the expense of manufacture. This applies where a number of different products are made and is not the same as (6).

The question of whether to departmentalize all charges is an important one, and must be decided, giving consideration to matters of product, information desired, processes involved, and so on, before a cost finding method can be worked out. If the nature of the product is such that it goes through all the processes

in the plant, with relatively the same manufacturing effort experienced by each, then no advantage in accuracy of costs will be gained by departmentalizing the charges. This, however, is seldom the case, which makes it advisable in most instances to carry all overhead or burden charges against departments. In one metal working factory that the writer recalls, the overhead, based on a percentage of direct labor, varied from 60% to 125% in ten or twelve departments. Thus it can be seen that nearly every cost (on articles having a different routing through the factory) would be different if a plant average were used in place of the departmentalized charges.

In working out the departmental burden charges, the different items making up the total factory burden can be assembled under five heads, namely: (1) building charge, (2) investment charge, (1) administration charge, (4) power charge, (5) direct charges to departments.

The building charge (1) is made up of rent or equivalent charges, heat, light, elevator service, janitor and watchman service, water, maintenance of buildings and grounds and building depreciation, unless they are included in the rent, and other items that relate to the building and can be divided among the departments on the basis of floor space used. The total of the charges grouped under this heading is then charged to each department in the same ratio that the department floor area bears to the total available factory area. If there is a general store room or general factory office, their area should be omitted from the total and the balance used in pro-rating the charges.

The investment charge (2) refers to factory equipment, and is made up of depreciation on equipment, taxes on equipment, interest if charged. Maintenance in many cases can be charged in here on the assumption that in general, maintenance cost is proportional to the value of the equipment, that is, a large machine, or a complicated and expensive smaller one, will require a greater amount of care and attention and repairs to keep it operating efficiently, than a small and simple inexpensive one. The total of these charges is carried to the various departments in the same ratio that its equipment investment bears to the sum of the department equipment accounts. Greater accuracy can be obtained in the depreciation charge, if desired, by working this out machine by machine for each department, and handling as a direct charge. Whether the additional accuracy is worth the extra work, when

considered in relation to the final results, is a question which must be decided in individual cases, depending on conditions and circumstances.

The administration charge (3) is made up of general administrative salaries and office expenses, factory administrative salaries, stationary, telephone and telegraph, factory clerical office help, experimental and engineering work, welfare, cost of employment, and any other charges that pertain more to the executive end of the factory operation than to building or investment charges as above described. It should be noted here that the classifications above referred to, are for distributive purposes only, the main considerations being whether the various details that make up the total charges can be most equitably distributed on the basis of floor space, value, or administrative factor.

Distributing the administration charge requires an arbitrary basis, and is the arbirtrary part of cost finding referred to previously. The following method has been applied in several plants with satisfactory and equitable results.

The administrative effort and expense expended in operating the departments of a factory are proportional to size as measured in square feet, to value of investment in equipment, and to the number of employees. We have a total expense made up of items which are perfectly legitimate, yet are general, and can not be said to be distributable to the departments except in an arbirtray way. Yet it is desirable to accomplish this as equitably as possible. Therefore, since the amount of administrative expense depends upon the three factors mentioned, it should be pro-rated accordingly.

The easiest way to distribute the building and investment charges is to calculate a percentage of each for each department. We will then reduce the number of direct-labor man-hours per department to a percentage. Then the percentage of the administrative charge per department will be

$$X = 1/3 \left(\frac{h}{H} + \frac{i}{I} + \frac{b}{B}\right) 100$$

where X = department percentage of administrative expense
h = no. of department man hours (direct labor)
H = no. of factory man hours
i = department investment value
I = factory investment value

b = department building charge

B = factory building charge.

Having previously figured each of the three percentages (i. e., building, investment, man-hours) the formula could be expressed

$$X\% = 1/3\ (h\% + i\% + b\%)$$

The power charge per department (4), is found either by measurement or by estimating the proportional amount of power used considering the rated horse power of motors, and probable average load, for electrical power, and corresponding measurements or estimates for pneumatic, hydraulic, gas, or steam power. As the power requirements vary so greatly in nearly every department of a factory, it is advisable to make a careful analysis and survey of each before making up the charges. This is really an engineering problem and is a good example of how cost and engineering work are related.

Direct charges (5), include all charges that because of their size or nature can not be included consistently under one of the other headings. An example is machine rental, which in some industries is an important item. Special equipment such as a high pressure boiler or superheater, refrigerating machine, pump, etc., that serve but one or two departments will also cause direct charges to be made against the departments served.

We now have the total make up of the monthly, quarterly or other period departmental burden, expressed for example as Dept. A, $750.00, Dept. B, $900.00, Dept. C, $600.00, etc. These charges can be distributed to production in accordance with the plans previously described, with the exception of the machine hour rate and process hour rate plans.

The machine hour rate plan of distributing factory overhead expense simply requires the same analysis and distribution of expense as previously outlined for departments, carried down to machines, expressed as so much per month, and then dividing by machine hours per month to get rate per hour. Machine in the sense used here means bench, or floor space, or special fixture, at which men work, as well as machines as ordinarily understood. The use of this plan requires a complete system for keeping the necessary records of production, man-hours, operations involved, etc., for applying the machine rate to factory costs when it is worked out.

The process hour rate is worked out like the machine hour rate except that a group of machines required in one process is used instead of individual machines. In figuring the cost of produc-

tion of an article, the number of process hours times the hour rate gives the overhead charge for that process.

In this paper the writer has attempted to bring out some of most important points to be considered in cost finding as well as present some ideas on distribution of overhead expense, and its analysis, that may be helpful. The average plant manager is somewhat afraid of the details of cost analysis and is averse to permitting much work to be spent along these lines. On the other hand, one who is conscientiously trying to find accurate costs, wants to get all the details as accurately as possible, and is liable to get into unnecessary refinement. The methods suggested here are admittedly not the most accurate, but considering consistency, results obtained, and work required, will be satisfactory and involve a minimum of detail and effort. In other words, we have tried to strike the happy medium between common-sense and efficiency on the one hand and unnecessary refinement, detail and red tape on the other. It is possible to finish a shaft accurate to within a few hundred-thousandths of an inch, but the ordinary tolerance is measured in thousandths, and that is all common-sense manufacturing allows except in special cases.

The big problem of any cost-finding plan is to get the first analysis and survey made and the methods worked out, after which continued operation of a properly developed cost system can be carried on by the average factory cost man.

CO-OPERATIVE BUYING SOCIETIES

A writer in the October, 1920, issue of the "Monthly Labor Review" gives an outline of the effects of the war on the co-operative efforts in European countries. In many of these countries a food panic began directly after the declaration of war and the prices of course increased rapidly. Everyone who had ready money endeavored to buy all the foodstuffs he could obtain. The co-operative stores sold all goods, however, at the usual prices to both members and non-members and in consequence their stock was reduced so rapidly that they began the practice of selling only to members. This in turn resulted in an enormous increase in the application for membership in co-operative societies of this kind. It at once became necessary to refuse all applications for new membership until conditions of wholesale food supply became more normal. The writer remarks that these co-operative societies were very effective in stabilizing the prices of food. —"Industrial Management," Jan. 1, 1921.

THE NEW CHICAGO TELEGRAPH BUILDING OF THE WESTERN UNION TELEGRAPH COMPANY

By W. W. Drew, '11
and R. A. Newlander, '18

It is a rather simple thing—this business of handling a telegram. You step up to the counter, write your message, hand it to the operator, he makes a few dots and dashes—the receiving operator copies it, the messenger delivers it. The work has been done. Such is the popular conception of the transmission of a telegram.

A description of the new Western Union seven story structure at 427 South La Salle Street will tell the real story of how telegraph messages are handled. This building is a modern steel and concrete fireproof structure, three hundred feet long by one hundred and fify feet wide, and is the largest building in the world which is devoted exclusively to telegraph purposes. It is never closed, functioning the entire twenty-four hours every day throughout the year.

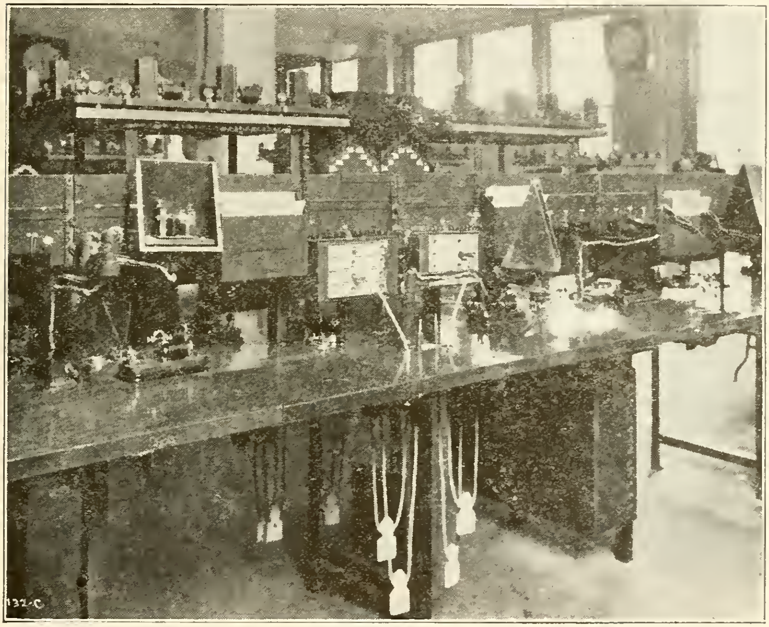
Nine million messages a month are handled in this office. The operating room covers three floors and by means of selective belt conveyors, messages received on circuits are routed to the proper wires of destination on an average elapsed time from wire to wire of about two minutes. To handle this large volume of traffic an operating force of three thousand persons is required. In addition to the operators, the new building houses one thousand other people who are employed in bookkeeping, auditing, plant and commercial duties.

In large cities, messages are handled by four methods. Messages originating at branch offices or destined to patrons in branch office areas, are generally handled by Pneumatic Tubes, Telephone, or the well known Morse system. Occasionally, where branch offices have a considerable file of traffic to handle and are located too far from the main office to make Tube installation economical, Automatic printing telegraph apparatus is used.

Between large cities the Automatic printing telegraph system has, to a marked degree, supplanted the Morse. The Multiplex system which is largely used, provides for as high as four duplex channels on one wire, each one of which is operated by a sending and receiving operator at each end of the circuit, thus allowing

four simultaneous transmissions in each direction. These channels operate at speeds ranging from thirty-five to sixty words per minute, making possible the transmission of five hundred messages per circuit hour.

All of the methods of transmission with the exception of that by Pneumatic Tubes, require well trained operators. The new building contains a large number of well equipped school rooms where Morse, Automatic, and Telephone telegraphy is taught. It takes approximately twelve months of training to teach students enough of the Morse so as to enable them to work on very



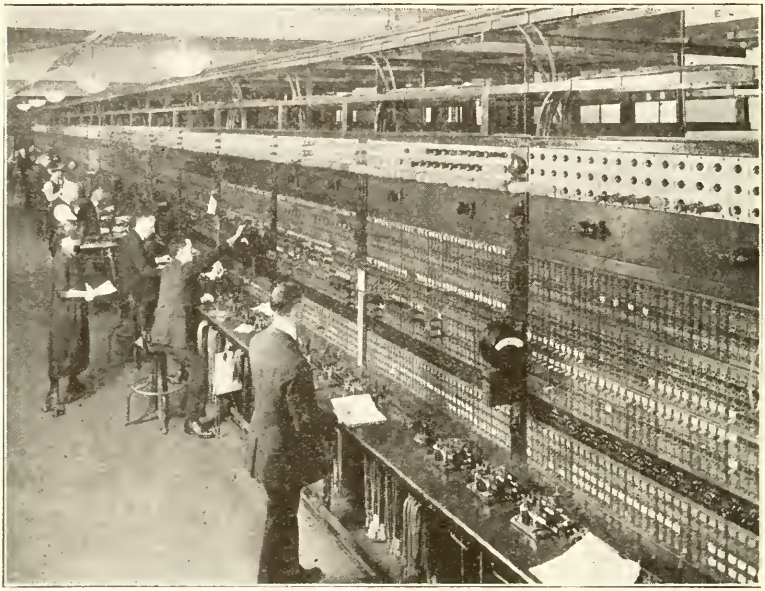
Close-up View of a City Line Concentration Unit.

slow wires; the Automatic training period requires three months; the Telephone course can be finished in about six weeks.

All city traffic, whether it is handled by Morse, Tube, Telephone, or Automatic methods, comes in on the fifth floor of the building. Here are located the terminals of the large underground Pneumatic Tube system which reach to all points in the loop and a few outlying branch offices. City wires which are operated by the Morse method are all terminated in concentration units so designed that four operators have direct access to each unit.

These units have terminated in them any number of city wires up to sixteen. The wires terminate in jacks and lamps, and the operators' Morse sets are wired to-cords and plugs.

The Telephone Department covers about one-third of the fifth floor and has its ceiling treated with felt to cut down the amount of noise. Noiseless typewriters are used in this department so as not to interfere with the telephone transmission and reception of messages. In this room messages are received from and delivered direct to patrons. The recording board when finished will



A Busy Moment on the Main Line Switchboard.

consist of forty positions for the reception of telegrams by telephone. There are also forty positions arranged for the delivery of telegrams and sixty-six for the handling of messages between branch offices and the main office.

Messages received on this floor are sent to the sixth and seventh main operating floors by means of belt conveyors. All receiving positions whether for Morse, Automatic, Telephone or Tube operation, are served by rapid belt conveyors which carry the messages from these positions to central distributing centers where they are routed to their proper wires of destination by a system of selective distributing belts.

All telegraph wires entering Chicago come through an underground cable system and terminate on a main distributing frame on the third floor. Here are also located twenty-seven sections of switchboard, repeater tables, and tables on which are located quadruplex and duplex terminal apparatus. The switchboards are of the latest pin-jack type and are equipped so that wire faults and failures can be quickly and accurately located.

On the third floor is also located the Dispatcher who keeps in touch by wire with traffic conditions all over the country and directs the setting up of additional or emergency circuits between cities for the handling of sudden files of traffic or for the diverting of traffic to other routes when regular routes have failed.

The Commercial News Department occupies part of the third floor for the handling of market quotations, baseball scores during the season, and news of other sporting events.

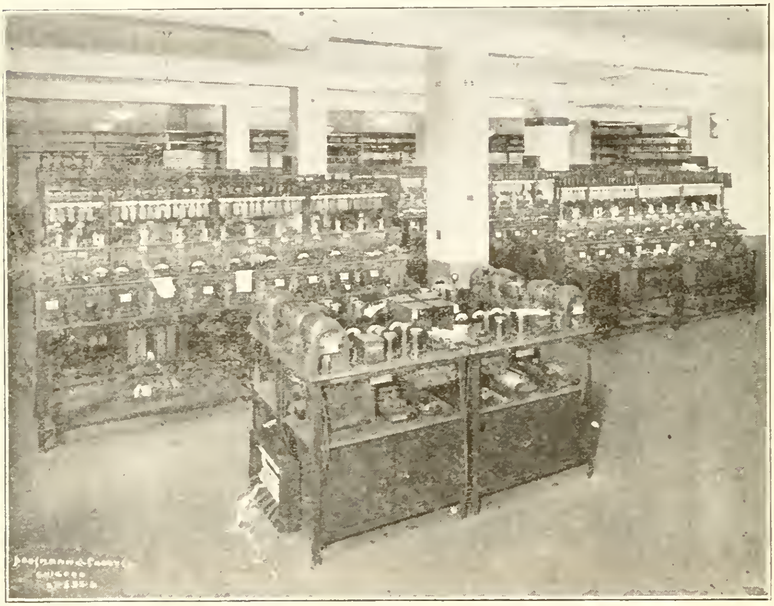
Power for the building comes in from the Edison Company at a potential of two hundred and twenty volts over six-one million five hundred thousand C. M. cables. This power is distributed for various uses through twenty sections of Tennessee pink marble switchboard. From these sections of switchboard, power feeders run to zone power panels located throughout the building.

The emergency power consists of two sets of twin unit seventy-five K. W. three wire Crocker-Wheeler generators, each directly connected to two semi-Diesel internal combustion oil engines of one hundred and twenty horsepower each. These engines are supplied with fuel oil from a ten thousand gallon storage tank located underneath the basement floor. Oil is drawn from this tank by an automatic pump and measuring device and delivered to smaller service tanks. The starting device for these engines consists of a supply of air pressure pumped up by electric pumps into storage tanks and maintained at one hundred and eighty pounds pressure. These engines can be started and put under full load within a period of seven minutes, thus insuring a minimum interruption to the telegraph service.

The lighting system is protected from failure by use of a storage battery and automatic emergency switch. In case of failure of the main source of power for the lights, this switch automatically operates and throws the lighting load on the storage battery until the emergency engines can be started.

The power for the operation of the telegraph circuits is supplied by means of twelve motor generator sets. These machines furnish one hundred and sixty, two hundred and forty and three hundred and twenty volts. Their control apparatus covers five sections of marble switchboard. All of these machines are duplicated so as to protect the service from interruption.

The power for the pneumatic tube system primarily consists of five seventeen by fourteen Laidlow-Dunn-Gordon air compressors, each driven by thirty-five horsepower motors delivering air



View of Repeater Department.

at from five to eight pounds pressure and maintaining a vacuum of from ten to sixteen inches.

The boiler room contains two water tube horizontally baffled boilers of the Heine type, each rated at three hundred boiler horsepower. These units are used for heating the building. The grates are the LeClade-Christie chain type. There is in addition to these two boilers one Kewanee firebox boiler for heating water for building and restaurant purposes during the summer months when the large boilers are shut down. There are two boiler feed pumps of the single acting type of sufficient size to handle the maximum boiler capacity.

The heating plan used is known as the direct-indirect system and is regulated by Johnson thermostatic controls. Radiators are placed in the usual way, that is, under the windows, and are supplied with steam from the low pressure control valves connected to a vacuum system fitted with Johns-Manville vacuum traps. The indirect system which is placed in two pent houses on the roof draws the air through two large fans of the squirrel cage type, one sixty inch in diameter having a capacity of thirty-one thousand seven hundred and eighty cubic feet per minute, and one sixty-six inch diameter of the same type and a capacity of thirty-three thousand five hundred and seventy cubic feet per minute. The air is drawn through air washers and then heated by means of large vertical radiators to a temperature of about sixty degrees "F." and delivered by means of air ducts to the operating floors. Exhaust fans by means of ducts and ceiling openings make a complete change of air every ten minutes.

The water supply for the building is taken from the city mains through two eight inch meters into a surge tank in the sub-basement, from which it is pumped into a house tank on the roof by means of two Worthington triplex pumps, six by eight inches, driven by fifteen horsepower Western Electric motors. The drinking water system consists of one five ton Krochell carbon-dioxide machine and one triplex circulating pump with proper cooling coils. The water for drinking purposes is taken from the hot water system at one hundred and eighty degrees "F'," cooled down to forty-five degrees "F," and filtered before going to bubblers located throughout the building.

There are two compressors supplying air for Shone Sewer Ejector system, automatically handling the sewerage and waste water below the city sewerage system. These compressors also furnish aid which is piped throughout the building for cleaning electrical and other machinery.

There are two company operated restaurants serving food at cost, one on the main floor for messenger boys and the other on the fourth floor for the other employees. The latter restaurant is of the cafeteria type and has a capacity sufficient to meet the needs of the thirty-five hundred employees in the building. All the baking and cooking is done in a modern equipped kitchen so arranged as to secure the best service at a minimum cost.

The building has a theater with a seating capacity of approximately three hundred, for use of the employees in staging amateur

productions and concerts. The second floor is given over to women's and men's rest and locker rooms. The rest rooms are equipped with rugs, tables, comfortable chairs, lounges and other furniture. A Victrola and piano are also provided. Each employee is provided with a steel locker for clothes.

For the recreation of the messenger force, a well equipped gymnasium with shower baths is available.

The second floor also houses a well equipped medical department, including a hospital where emergency cases may be promptly handled by a corps of trained nurses and a company physician.

On the roof of the building handball courts have been provided for use during the summer months. The roof will also be used for other recreative purposes.

FEDERAL AID FOR DRAINAGE PROPOSED

Government assistance in the drainage of swamp lands, protection of overflowed lands, and reforesting of cut-over lands is provided in a bill now before Congress, drafted by Edgar A. Rossiter, consulting engineer, Chicago. Such assistance would be rendered through the Department of the Interior with a fund provided by annual appropriations by Congress. Under the proposed plan any state reclamation board could call for an investigation of a project to determine such charge per acre on the lands affected as would return to the fund the estimated cost of construction, the board to have charge of construction. For operation and maintenance an additional charge might be made, but this work might be transferred by the Department of the Interior to a local drainage association or district. When any project includes a navigable stream which might be utilized for barge transportation the cost would be divided between the Federal government and the land-owners. Mr. Rossiter points out that Illinois alone has 10,000,000 acres of swamp and overflowed lands, but that State laws provide no relief, while the Federal reclamation act establishes a precedent for such improvement work as is covered in the proposed bill. He states that arid lands are worth $50 to $100 per acre when irrigated, but that swamp lands are worth $200 to $350 per acre when drained.

—Engineering News Record.

THE ROOSEVELT ROAD VIADUCT.

By Morris Grodsky, '15
Formerly Senior Bridge Designing Engineer, City of Chicago

Historical.

Roosevelt Road (formerly 12th Street) is one of the main arteries of Chicago. It is situated at the south end of the downtown district and is the connecting link between that district and the West Side. Most of the railroads entering Chicago from the south have their yards and freight stations near Roosevelt Road. The railroad tracks crossing Roosevelt Road extend from State St. on the east to Canal St. on the west. .

A steel viaduct carries Roosevelt Road across this maze of tracks. This structure was built in 1880 and consists of several through trusses and trestle spans. It is inadequate as a thoroughfare for the present traffic (it is only 80 ft. wide), besides being old and eaten by rust.

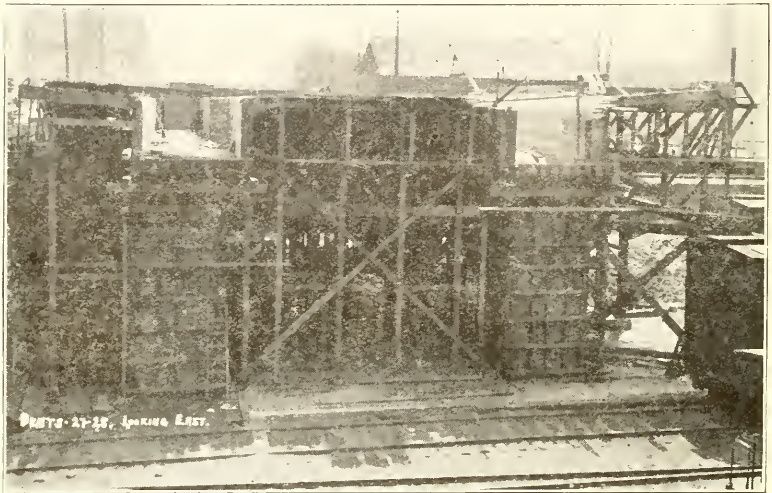
The 12th St. Improvement Ordinance passed by the City Council for widening the then 12th St., throughout its length is 118 ft., replacing the old viaduct by a new structure, removing the present swing bridge over the South Branch of the Chicago River by a single leaf bascule bridge.

The bridge division of the city then designed the viaduct. The roadway and sidewalk consisted of small-span concrete slabs framing into steel stringers, which in turn framed into steel cross girders. The stringer spans were made unequal in length in order to accommodate track spacing under the viaduct. The stresses in the stringers were analyzed by means of the three-moment theorem and temperature stresses were guessed at in the usual way. The steelwork was to be encased in concrete for firepoofing. The plans were completed in 1917.

At that time the shipbuilding and other war industries had the priority on structural steel; little was available for private or municipal construction, especially in such large quantities as was required for the viaduct. The end of the war was then not in sight; postponing the viaduct was not desirable. Accordingly the engineers in charge of the improvement began to think of a concrete structure.

The railroads whose tracks go under the viaduct were directly interested in this improvement, as they were required to pay a part of the cost of the viaduct as well as to maintain the viaduct

after ten years from the date of its completion. After negotiations between city officials and representatives of the railroads, it was agreed to build the viaduct of concrete, provided the column spacing were to remain as in the previous design. It was also agreed that the city would build the part of the viaduct east of the Chicago River (as well as the bascule bridge across the river), while the Chicago Union Station Co. would build the part west of the river.



The first study of the concrete viaduct made was of a flat slab structure. The width being such (118 ft.) as to allow several panels transversely, the design adapted itself to flat-slab. But the difficulty encountered was the longitudinal column spacing. For flat-slab more or less uniform column spacing is required; but the layout of tracks under the viaduct and the required clearances between columns and rails did not allow a uniform spacing. Hence this design was abandoned.

A study was then made in a beam and girder design. Slabs were spanned between stringers placed close together. The stringers framed into cross-girders, which were supported by columns. It was the same as the old steel design, with the steel members replaced by concrete.

At this time, Mr. R. R. Leffler (then with the Bridge Division) submitted a design consisting of slabs spanning between four rows of longitudinal girders, thus eliminating the stringers. The

relative merits of the two designs will be discussed later. These two designs were brought before the Chicago Plan Commission, which decided in favor of Mr. Leffler's design. However, the Chicago Union Station Co. adopted for the west part of the viaduct a beam and girder design and could not be persuaded to adopt the city's design. Thus it happened that the two parts of the viaduct have different structural features.

General Description.

The Roosevelt Road viaduct extends from Wabash Ave. to Canal St. The South Branch of the Chicago River divides the viaduct into two parts: The east half and the west half. The east part begins at Wabash Ave. with a 219 ft. filled approach and continues to the Chicago River with 1788 ft. of viaduct. Clark St. is elevated north and south of Roosevelt Road to meet the viaduct. The Clark St. approaches consist of 500 ft. of filled approach and 335 ft. of viaduct to the north of Roosevelt Road and of 550 ft. of filled approach and 335 ft. of viaduct to the south of Roosevelt Road. The viaduct is also reached by an approach on Wells St. On this approach 108 ft. adjacent to Roosevelt Road will be built of concrete, while for the remaining 546 ft. the old steel approach will be used after raising it to meet the new grades.

The West part of the viaduct begins at Canal St. with a 245 ft. filled approach and continues to the Chicago River with 1072 ft. of viaduct. At Lumber St. a ramp is built to reach the viaduct. This ramp is about 600 ft. long. The Chicago River is spanned by a single leaf bascule bridge of the Chicago type. The bridge has four trusses of varying spans, as the opposite banks of the Chicago River are not parallel to each other. The shortest span is 182 ft. 3½ in. and the longest is 211 ft. 10⅞ in. The bridge is 90 ft. wide and has a 56 ft. roadway with 17 ft. sidewalks on each side of it.

The Roosevelt Road viaduct is 118 ft. wide. In the center of the viaduct is a 25 ft. island carrying the two street car tracks. On each side of the street car island is a 29 ft. 6 in. roadway for vehicular traffic and a 17 ft. sidewalk for foot traffic (see Fig. 1). The Clark St. approaches are 50 ft. wide and consist of a 6 ft. sidewalk on the east side of the approach, a 42 ft. roadway and a 2 ft. curb on the west side of the approach. The Wells St. approach is 60 ft. wide and flares out to 104 ft. at Roosevelt Road

to allow the street cars to turn from Wells St. to Roosevelt Road and vice versa. The Lumber St. ramp is 40 ft. wide.

Design Features.

The 12th St. Improvement Ordinance provides that the construction of the new viaduct go on without interrupting traffic. The old steel viaduct occupies the north half of the widened street. Hence it was decided to build the new viaduct in two halves. The south half is to be built first, the traffic meanwhile using the old viaduct. When the south half of the new viaduct is completed and linked up with the bridge, traffic will be switched onto it, the old viaduct taken off and the north half of the new viaduct built. Thus the viaduct is designed and built in two identical and independent units.

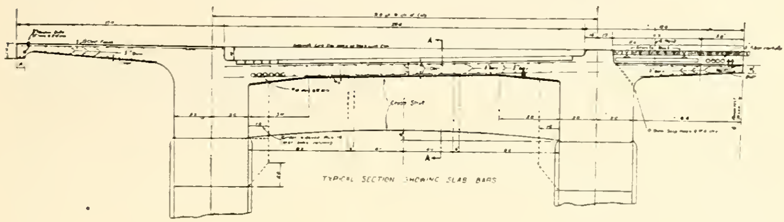
In general the structure consists of slabs carried on four lines of longitudinal girders. These girders frame into rectangular columns resting on caissons which are carried to bedrock. The column sizes as adopted allow maximum clearance between railroad tracks under the viaduct. For the same reason the columns are often placed at a skew with the center line of the viaduct. The expansion joints occur about every 200 to 240 ft. The sections between expansion joints are made entirely independent of each other by placing a double column at the joint.

The design adopted for the East part of the viaduct differs from the usual beam and girder construction in many respects. In the so-called beam and girder construction the slab is carried by closely spaced stringers. The stringers frame into cross-girders, which in turn are framed to the columns. In this design the slab, although spanning a short distance between stringers, must be made heavier than required for the load it carries, in order to get the minimum thickness considered to be good practice for slabs exposed to impact.

In the design adopted for the viaduct east of the river, each half consists of a roadway slab spanning between two longitudinal girders. The clear span of this slab is 25 ft, 6 in. The girders are ordinarily 6 ft. wide. To one side of the roadway slab is a sidewalk slab cantilevered from the girder; to the other side, another cantilever slab carrying the street car. Fig. 1 shows the cross-section for one-half of the viaduct only (the other half is the same as but opposite hand to this one). The sidewalk slab is cantilevered 13 ft.; the street car slab, 8 ft. 6 in. The advan-

tage of this arrangement lies in the fact that the two cantilever slabs supply continuity to the roadway slab, giving in effect a three-span continuous slab. This reduces the positive moment in the roadway slab and permits its spanning 25 ft. 6 in. between girders. Another advantage of this arrangement is that it is only necessary to design one foot of slab; the design can then be applied for the full length of the viaduct, since the cross-section does not change except at street intersections.

The great number of stringers of the beam and girder construction are combined in the viaduct design into two girders (for each half of the viaduct). Each girder is 6 ft. wide; but where



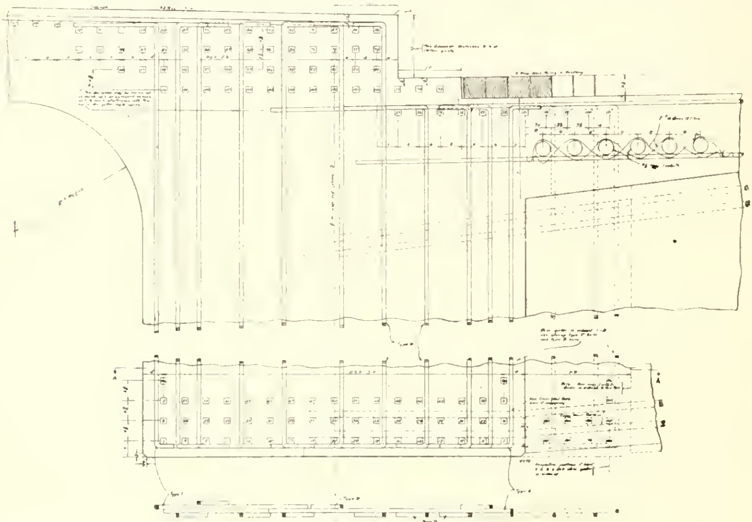
required by high unit shear to be wider, it is made 7 ft. 8 in. wide. The depth of the girder is made varying according to the span lengths. The girders are rigidly framed to the columns by means of haunches. The columns are 6 ft. 7 in. wide and 2 ft. 6½ in. thick for expansion joint columns and 2 ft. 8 in. thick for others. This simplifies the calculations of stresses in the columns.

To balance the bending moments induced by possible unequal loading of the cantilever slabs, struts are put in about every 30 ft. They span across the girders thus taking moments due to torsion in the girders. In order not to complicate the stresses in these struts, a ¾ in. crack is left between them and the roadway slab above. This allows the slab to deflect without bringing any load on the struts.

The viaduct cross-section outlined above possesses certain advantages. It is simple and applies throughout the length of the viaduct. The slab, strut, girder and column dimensions are standardized. This simplifies the formwork and allows it also to be standardized. The fact of using only two girders reduces the amount of forms used from 15 to 20%.

This design permits also the simplification of the reinforcing steel. The steel in the slabs and struts is the same throughout the

length of the viaduct. The girders being largely of one width, admit standardization of the top and bottom reinforcing. As shown in the girder section, Fig. 2, bars having the same identification numbers are placed in the same relative positions in all girders. Again no bent bars are used in the girders. The stirrups are the same in number (11 for the 6 ft. width, 14 for the 7 ft. 8 in. width) in all girders, and are of a shape easy to hook around the longitudinal reinforcing. In the columns steel is used only in certain combinations. The steel used is about 95% base (that is ¾ in. and above in size). This means a lower



SECTION AA SHOWING PLAN OF STIRRUPS

unit price; it also means that for a certain tonnage there are fewer bars to place, thus showing a saving in the cost of laying steel. Again the percentage of bent bars is smaller than usual, being only about 30 to 35%, also reducing the cost of steel.

The computation of the amount of live load coming on the girders is greatly simplified, as there are no stringers to bring on concentrated loads. The amount of live load coming from the slabs is always the same, giving the girders a uniform live load.

The design lends itself readily to analysis as a rigid frame. The girders are continuous over and stiffened by the columns. Together they form a vertical rigid frame between expansion joints. In the beam and girder construction most of the stringers are

not in line with the columns. They are continuous over the cross-girders. But together with the cross-girders they do not form frames lending themselves to analysis, as the stiffness of the stringer supports is difficult to determine.

From the architectural standpoint the design also possesses advantages. The beam and girder construction is an imitation of the typical steel design with short spans for slabs and many stringers. It is in fact of the same appearance as steel encased in concrete. The new design is adapted specifically to concrete: it is massive and has few and simple lines. It eliminates the great number of unsightly beams, underneath the structure, substituting for them arched girders blending into the columns. The architectural features of the viaduct were worked out in co-operation with the Chicago Plan Commission. Such parts as the heavy concrete railing on the viaduct, the fascia beam, the curve of the haunches, the vertical lines of the columns, the ornamental iron railing on the approaches, etc., received the attention of the Chicago Plan Commission. To prevent an illusion of sagging to which concrete girders of long spans are subject, they were cambered an amount proportional to their span lengths (1 in. for every 12 ft. of span between curved haunches).

Loads and Unit Stresses.

The dead load consisting of the weight of the slabs, railings, pavement, street car ballast, struts and girders is considered uniformly distributed over the girder span with a value of 13000 lbs. per lin. ft. of girder supporting the sidewalk and 12000 lbs. per lin. ft. of girder supporting the street car slab.

The specifications used for live loads and stresses were "Specifications Governing the Construction, Repairs and Rebuilding of Viaducts Over Railroad Tracks," issued by the Bureau of Engineering, Dept. of Public Works, City of Chicago, January, 1917. According to these specifications the roadway slab is designed for a 24 ton truck, concentrating 12000 lbs. on each wheel. Space not occupied by the truck is covered with a uniform live load of 100 lbs. per sq. ft. The impact allowance is taken as $I = S \frac{50}{L+150}$, where I is the impact increment, S is the computed maximum live load stress and L is the length of the load producing maximum stress. The wheel concentrations are assumed to spread in a

manner described in the specifications and an equivalent uniform live load for the roadway slab is obtained as 220 lbs. per sq. ft. (including impact). The street car cantilever is designed for a live load of a 50-ton street car and 100 lbs. per sq. ft. on the area unoccupied by the street car. The equivalent uniform load is computed as 285 lbs. per sq. ft. (including impact). The sidewalk cantilever is designed for a live load of 100 lbs. per sq. ft. without allowance for impact.

The live load on the girder supporting the sidewalk and roadway comes from a 24-ton truck, 100 lbs. per sq. ft. on area unoccupied by the truck, 100 lbs. per sq. ft. of sidewalk and a cantilever reaction due to a live load on the sidewalk cantilever with no live load on the street car slab. Impact is allowed as per specifications. The resulting live load is taken as 4600 lbs. per lin. ft.

The live load on the girder supporting the roadway and street car slabs is taken in a similar way, replacing the 100 lbs. per sq. ft. on the sidewalk by a 50-ton street car with 100 lbs. per sq. ft. on area unoccupied by street car. The resultant live load is 5600 lbs. per lin. ft. (including impact). Thus for the loads on girders:

Dead load on sidewalk girder.............	13000 lbs. per lin. ft.
Live load on sidewalk girder.............	4600 lbs. per lin. ft.
Total load on sidewalk girder.............	17600 lbs. per lin. ft.
Dead load on street car girder.............	12000 lbs. per lin. ft.
Live load on street car girder.............	5600 lbs. per lin. ft.
Total load on street car girder.............	17600 lbs. per lin. ft.

For the sake of uniformity, the dead load for both girders is taken at 13000 lbs. per lin. ft. and the live load, at 4600 lbs. per lin. ft.

The tractive or longitudinal forces are taken at 20% of the moving live load on one track, thus giving 20000 lbs. as the horizontal force for each half of the viaduct.

For the calculation of temperature stresses a basic temperature of 65° F. is assumed with variations of 40° up to +105° F. and of 80° down to —15° F. The expansion joint is made 1 in. wide at 65° F. with a proportional variation if construction is carried out at a different temperature.

The unit stresses are taken according to the specifications: 750 lbs. per sq. in. for compression in extreme fiber due to bending in 1-2-4 concrete; 16000 lbs. per sq. in. for tension in steel (Note: Only structural grade plain bars are used); 450 lbs. per sq. in. direct compression on 1-2-4 concrete; shear without web reinforcing—40 lbs. per sq. in.; with web reinforcing—120 lbs. per sq. in.; bond—80 lbs. per sq. in. on plain bars. The value of n is taken at 15 for 1-2-4 concrete.

Method of Analysis.

The roadway slab was designed as continuous over rigid supports. For dead load a moment of $\frac{w\,l^2}{12}$ at the support and $\frac{w\,l^2}{23}$ at the center was used. For live load, $\frac{w\,l^2}{12}$ was used for moment both at the support and at the center. For the cantilever slabs the usual moment coefficients were used.

Each line of girders with the columns between expansion joints was treated as a rigid frame. The reasons for not using the ordinary simple methods of analysis (as the three-moment theorem), were the following:

1. In order to clear the railroad tracks under the viaduct, columns had to be put at convenient places without giving due regard to equal span lengths. The columns are rigidly connected to the girders and therefore are liable to bending moments due to loads on the girders. The unequal column spacing may cause heavy moments in the columns from the dead load alone.

2. The live load on the viaduct is of the moving type. The moments induced in the columns due to the moving live load in a monolythic structure are considerable, especially as the column spacing is irregular.

3. The distance between expansion joints amounts to 240 ft. and over in several cases. Temperature changes will cause considerable stresses in this distance between joints. The usual practice of analyzing the temperature stresses is to assume the amount of contraction or expansion as a deflection of the upper end of the column (considered free to move), while the lower end is held rigid. In other words, the column is considered as a cantilever restrained at the bottom and deflecting at the top an amount equal to the contraction or expansion of the girder from

the center of the frame to the column in question. The stresses caused by such a deflection are assumed to be equal to the temperature stresses in the columns. However, since the frame is unsymmetrical and doubt may arise as to the amount of deflection in each column; and since the columns are rigidly connected to the girders instead of having their upper ends free to move, thus causing difficult stresses in the columns; this method of obtaining stresses in columns due to temperature changes is primitive and cannot inspire confidence in the results obtained by it.

These factors make it necessary to design the girders and columns as a rigid frame. Of the known methods of analyzing rigid frames, the Slope-Deflection method possesses the advantage of greatly reduced computations. This decided the use of that method in analyzing the frames.

The slope-deflection method of analyzing rigid frames is based on expressing the moment at any point in terms of moment at the joint of column and girder. The moment at the joint A of any member AB, $M_{ab} = 2EK\left(2\theta_a + \theta_b - \frac{3d}{l}\right) + C_{ab}$, where M_{ab} is the moment at the end A of member AB, K is the ratio of the moment of inertia of the member to its length, E is the modulus of elasticity of the material, θ_a and θ_b are the angles made by the tangents to the deformed neutral axes with their original positions at A and B respectively, d is deflection at right angles to the member AB of end B relative to end A and C_{ab} is a factor depending upon the load and is equal to the bending moment at the support A of a beam AB (fixed at both ends) of the same loading and span as the member AB.

In analyzing the frame, expression for moments (similar to the above expression) for the ends of each member in the frame and for various conditions of loading are written. The sum of such moments around each joint must equal zero for equilibrium. By considering that the sum of the horizontal reactions at the foot of the columns must equal zero for the cases of vertical loading and temperature variations; or must equal the horizontal load in case of such a load—another equation may be obtained. For frames with one tier of columns (that is one story in height), the number of equations thus obtained will be equal to the number of

unknowns. These equations are solved simultaneously and values for moments at the joints are obtained for various conditions of loading. Knowing the moments at the joints, the moment at any other point can easily be calculated. Moment diagrams for various loads are plotted and from these the combination giving the maximum moments is obtained. The calculations are not shown here, as they occupy too much space.

Note: The columns rest on caissons, hence unyielding supports were assumed. Also the columns were assumed fixed at the tops of the caisson caps.

Special Features.

The viaduct at State St. consists of three arched spans: one over each sidewalk with a 15 ft. clear opening and one over the roadway with a 60 ft. 8 in. clear opening. The columns into which the arch ribs frame are placed at the street lines and at the curbs, giving unobstructed roadway and sidewalks. There are 6 arch ribs across State St. The exterior ribs are 6 ft. wide, the four interior ribs are 12 ft. 7 in. wide. The exterior columns are 4 ft. by 6 ft. 11 in.; the interior, 4 ft. by 14 ft. 1. in. Connecting the arch ribs are two slabs. One at the top of the rib serves as sidewalk or roadway for the viaduct; the other, at the bottom of the rib, serves as a ceiling for the subviaduct space. The space between these two slabs was left hollow in order to save weight (and dead load). The ceiling slab is arched in a transverse direction, which together with its curving in the longitudinal direction, gives a groined effect. The columns are connected in a transverse direction by small arch ribs.

On top of the viaduct the usual heavy reinforced concrete railing gives way to a balustrade of graceful outlines. Four stairways, one in each corner of the street intersection, connect the upper level with the street. The stairways are of reinforced concrete, each one consisting of a slab resting on two arched stringers. The stairway railing is of ornamental iron.

The balustrade, the ornamental iron railing and the face ornamentation on the exterior arch received special architectural treatment and were approved by the Chicago Plan Commission.

Structurally, the crossing presented a difficult problem. The thickness of the interior rib effective to resist moment from the loaded 60 ft. 8 in. clear span was only 2 ft. 5 in. This was caused by the fact that on the one hand the State St. crossing is near

the east end of the viaduct and the elevation at the crossing could not be raised without bringing the approach grade above the practical. On the other hand, clearance for street cars had to be provided under the arch. The approach grade was given the maximum value to which the Chicago Surface Lines would agree, viz.: 3.4%. State St. underneath was depressed about 2½ ft.; then only giving 2 ft. 5 in. as effective depth for the interior ribs. To make an expansion joint through the center of the roadway arch and thus create two cantilever arches, was not desirable, as the joint would be difficult to hide and would mar the face ornamentation on the exterior arch.

To get out of the difficulty, the three arch spans were considered as continuous. The sidewalk arches were made very heavy in spite of their small spans; this together with the heavy columns caused a large moment at the springing of the roadway arch, which reduced the moment at the center sufficiently to allow the use of the shallow ribs.

Another interesting feature occurred at the river end of the east part of the viaduct. The section between the last expansion joint and the east abutment of the bascule bridge consists of two spans averaging about 65 ft. each. The Wells St. approach joins the viaduct at this section and the street cars from Wells St. cross over to the viaduct. This necessitated a heavier construction, resulting in larger loads for the girders.

The columns are on skew to the viaduct and so are stiffer than when usually placed at right angles to the viaduct. The combination of heavier loads, a section with only two spans, and columns stiffer than usual, causes high stresses in the columns. In addition to this the girder seat at the abutment practically fixes this end of the section. The resulting temperature stresses in the columns when added to the dead and live load stresses, make the columns unsafe.

It was desirable to obtain movement under temperature variations at the abutment seat of the frame. At first a phosphor-bronze plate on the abutment seat and a cast-iron plate as a shoe on the girder were tried. The resulting coefficient of friction, however, would still be large enough to overcome the horizontal reaction obtained when this end is considered fixed. Thus no movement would occur.

Recourse was then had to rollers. Three 12 in. segmented rollers (4¾ in. wide and 2 ft. 8 in. long) were placed on the

base casting. On top of the rollers were placed: a lower pin-casting, a 6 in. pin and an upper pin-casting fastened to the bottom of the concrete girder. The pin turns in phosphor-bronze bushings. The upper pin-casting is fastened to the girder and the base casting to the abutment seat with four 1½ in. round bolts each. This arrangement, allowing movement in the frame under temperature variations, brought the column stresses down to a safe limit.

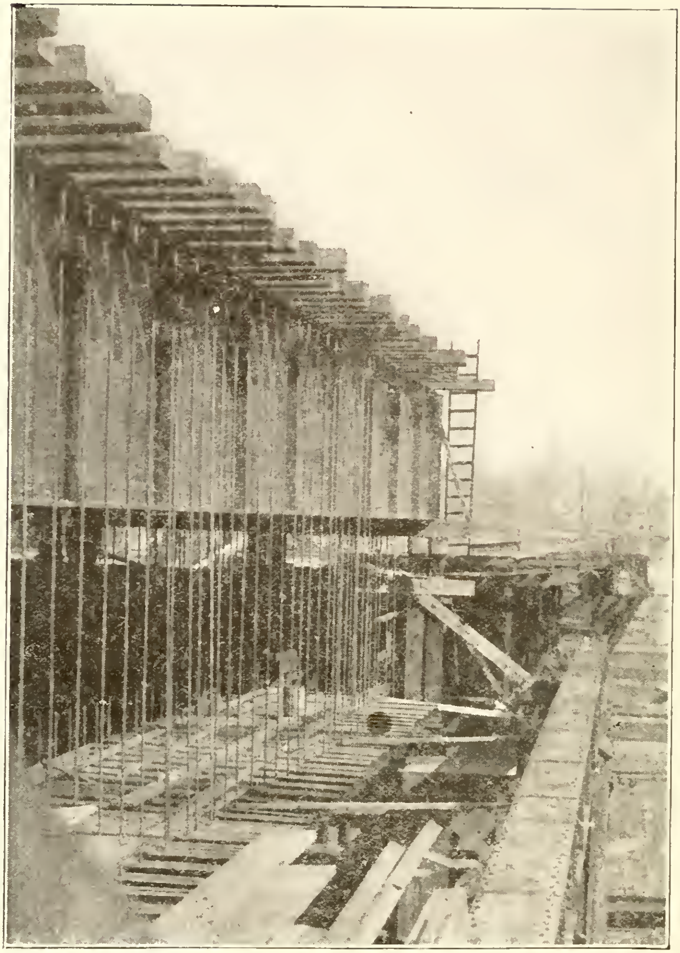
Formwork.

As was described above, the cross-section is typical throughout the viaduct. This means that the forms for the slab are the same for the entire length of the viaduct; the curved soffits of the cantilever slabs and the haunches near the supports of the roadway slab are also typical. The same is true of the girder, their width being constant (either 6 ft. or 7 ft. 8 in.). The struts have the same dimensions in all cases. The interior columns are all alive, as well as the expansion joint columns. This simplifies the forms to a great extent and allows them to be used several times.

But simple as the forms are, the falsework presented a complicated problem. There are only a few spans without any railroad tracks underneath, where a regular timber trestle can be built to support the formwork. In those cases the forms were supported in the usual manner by joists framing with beams, supported by posts, etc. (See Fig. 3.)

In a number of cases the girders crossed one or two tracks close together, about 14 ft. on centers. Then timber posts were set up on the outside of the tracks, I beams were laid over the posts spanning the tracks and the forms were supported by the I beams.

In several cases where a cluster of tracks crossing the lower level of the viaduct, and where no clearance under the viaduct existed to permit the forms to be supported by girders spanning the tracks, the forms were supported from overhead. Six steel girders were placed in a longitudinal direction above the top of the future concrete and supported either on the adjacent concrete (if already poured) or on timber trestles. Timbers were laid across these girders with a uniform spacing; long bolts were carried from these timbers down through the formwork, support-



ing the I beams which hold up the forms. Fig. 4 shows this arrangement previous to the pouring of concrete.

Under these conditions, the formwork could not be built haphazardly, but was carefully designed and built from designs as closely as conditions on the job permitted. The fact that the forms repeat was an incentive to turn out the most economical forms. Again the difficulty of supporting them made a detailed study necessary. The Designing Division of the Bureau of Engineering accordingly made designs and details for every span of the viaduct, where there were tracks underneath. They de-

signed the overhead supports, girders, I beams, timber trestles, etc. Their plans guided the men on the job wherever possible, and gave a solution to each falsework problem as it presented itself.

Plant.

Several schemes were presented to bring about an efficient handling of the materials and distribution of the concrete. Among them was one to build a narrow gage railroad on top of the existing steel viaduct, leaving sufficient clearance for traffic; to have one central plant and to distribute the concrete by means of small cars to points where it is needed. This scheme was abandoned because of the inability of the present steel viaduct to withstand the extra load and the vibration.

The scheme finally adopted was to use three plant layouts, one at State St., another to the east of Wells St., and the third at Clark St. The first layout will take care of about 620 ft. of viaduct; the second, of about 725 ft., and the third, of about 420 ft. on Roosevelt Road, and in addition the Clark St. approaches.

The plant equipment consists of two 1-yd. electric-driven Milwaukee chain-belt mixers, one distributing tower, one electric hoist and chutes.

No extensive storage facilities were provided. Enough material is kept on the job to run the plant for about a half day Arrangements with local supply companies were such that a practically uninterrupted supply of materials was insured during periods of concreting.

The concrete distribution was effected by hoisting the concrete in a tower and bringing it to the desired location by a system of spouts.

Concreting.

In order to make the slabs, girders and columns act together, as was assumed in the analysis, it was necessary to insure a monolythic structure. To that effect construction joints were placed only at center lines of bents. Between bents concrete is poured in one continuous operation. To guard against interruption of concreting due to a breakdown of a mixer, an extra mixer is kept ready to start and continue the concreting. All the concrete poured (with a very few exceptions) is of 1-2-4 mix. The concrete in the abutment is of 1-3-5 mix. The sidewalks are covered with a 1-in. granite finish within 54 min. after the slab is poured.

Cost.

A correct estimate of the cost of the east part of the viaduct is impossible. The prices of labor and material have changed so much since construction started, and will no doubt keep on changing in the future until the job is finished, that it is impossible to forecast the cost of the entire improvement. However, the substructure on Roosevelt Road east of the river, including the caissons, caisson caps, caisson beams and subcolumns built in 1919, cost $500,000. The superstructure is at the present time about 40% completed, but unit prices so far are not available. Even if they were, they would not be indicative of the cost of the entire superstructure, as prices in the future will no doubt be different

Organization.

The viaduct is built by the Bureau of Engineering in the Department of Public Works. The plans and specifications were prepared in the Designing Section of the Bidge Division. Mr. T. G. Pihlfeldt was at the head of the Bridge Division; Mr. H. E. Young, of the Designing Section. Now, Mr. C. S. Rowe and Mr. J. R. Hall, respectively, occupy these positions. The plans were prepared under the direct charge of the writer. The construction is done by the Construction Division, under Mr. J. J. Versluis. Mr. J. Cermak is in direct charge of the construction. Mr. H. B. Anderson is the resident assistant engineer.

TO MOVE TOWN SO AS TO BE ABLE TO BUILD DAM

It now seems practically certain that in connection with the construction of the American Falls reservoir on the Snake River in Idaho, legislative authority will be given to purchase, condemn, and improve land for a new town site to replace the portion of the town of American Falls which will be flooded by the new reservoir. The project calls for a 90-ft. dam, which would impound 3,000,000 acre feet and make available for irrigation the entire water resources of the Snake River.

In addition to moving a large part of the town of American Falls it will be necessary to acquire the 6000 h.p. hydro-electric plant of the Idaho Power Company located just below the dam site. The proposed dam would make necessary the relocation of several miles of the Oregon Short Line Railroad. Indian lands as well as private lands would be flooded . This calls for time-consuming adjustments. All of those matters, however, are to be carried forward as rapidly as possible. Thus far arrangements have been concluded for the use of less than 1,000,000 acre feet. —Electrical World, Feb. 26, 1921.

STANDARDIZATION OF LUMBER

By Charles Edward Paul.
Professor of Mechanics, Armour Institute of Technology.

The United States Forest Service estimates that there are two thousand, two hundred and fifteen billion feet of saw timber standing in our forests today. As a concrete example of the magnitude of this supply, if all the timber in only the states of Washington and Oregon was cut and loaded into freight cars containing 30,000 feet per car, it would require 114,000,000 cars for Washington and 77,700,000 cars for Oregon.

The lumber industry as a whole, with its raw material scattered widely over about thirty per cent of the surface of the United States and bringing its products to the building material markets in every city and village, is vast in its physical and commercial resources, immensely important in its position in the building field, but sadly deficient in its structural standards.

What is Standardization?

A material is standard when it meets definite qualifications which are set up and established by authority as rules for the measure of quantity, quality, extent, or value. At the present time, each regional association of lumber manufacturers has its own separate set of standards for the size and quality of the commercial product which its members cut from a given species of tree. Even logs from the same district, or tree, if delivered to manufacturers belonging to different regional associations, would be cut into material for the consumer under two different standards as to size and commercial grade for the same quality of material. This multiplicity and diversity of standards, places the industry in a position such that it has no standard that can be applied to lumber in general, although each regional association of manufacturers produces a material which has a common use in many or all purposes.

Who is Interested in Standardization, and for What Reason?

The Consumer—Consumers of wood, including the designer, the contractor, the architect, and the engineer, are interested in definite standards of size and grade on account of the great confusion now existing in these points which are of extreme importance to them in their work. They can see no reason why a piece of dimension commonly referred to as a "two by four" should be 1 9/16" x 3½" in one book of grading rules, and 1¾" x

3¾″ in another. Nor can they understand why the grade of "No. 1 Common" should have very different specifications in the rules of different associations of manufacturers. The consumers do not request or demand that material shall be full rated size, or that it shall meet any requirement as to quality set by them, but they do want a rated size and a given name to mean the same thing with all manufacturers of lumber.

The finished structures in which wood is used by these men have very definite dimensions. Combinations of various pieces of wood when used one on the other are required to produce finally a given thickness, or lead bearing capacity. Uniform standards as to size and quality would allow the development of standard units of design, which could be used with certainty as to results obtained. As the situation exists at present, these men must investigate particular variations in sizes and specifications as to grade for each kind of lumber used in a structure before they can proceed with its calculations. A design which is correct in one section of the country may be entirely inadequate in another section, even though the same *nominal* sizes of material are used. This makes it far easier for the designer to use competing materials which have very definite standards throughout the country.

The Distributor—The distributor of wood products, as for instance the retail lumber dealer, is interested in standardization of lumber since he realizes the present difficulties which the consumer faces, and can see no absolute need for such a condition.

Variations in the same nominal size in different species of lumber cause confusion in his yard stock. His yards are filled with all kinds of thicknesses and widths, and no one knows the loss and trouble which is entailed.

The consumer accuses him of selling extra scant sizes and proves it by going into his yard and showing him the same nominal size of material that measures larger than the kind he delivered.

He is in controversy with building inspectors and often cannot furnish material that will meet the requirements of city ordinances which were framed in the days when a "two by four" was a "two by four."

He knows that diminished sizes have upset the few standard tables that the designer depended upon for his load carrying

members, and that a vast wave of general protest is forming. Such a condition does not help his business.

The Manufacturer.—The manufacturer in general is interested in standardization because he recognizes that the complaints of the consumer and the distributor of his product are just and reasonable. He wishes to furnish a material which will meet the public demand, but fears that a change in his present sizes and methods of grading may interfere more or less seriously with the routine of his business. He knows that the demand for standardization has reached the point where something will be done to remedy the present situation. He hears that national engineering and architectural societies have decided to formulate their own standards and then base their orders for lumber on these standards. Needless to say their proposed standards do not take into account the possible disturbance which may be caused in the lumber industry. Even rumors of legislation have been heard which would specify finished sizes of lumber to be the same as present nominal sizes.

The manufacturer realizes that such standards of size and quality can be developed best in the industry where the material is best known. In this way, the demands of the consumer can be met with the least disturbance in present manufacturing rules and processes. Co-operation with the consumer through representative engineering or architectural societies and with the Forest Products Laboratory, Madison, Wisconsin, should produce standards which will satisfy the consumer as well as the producer and have a real technical basis.

What Will Be the Effect of Standardization?

True standardization for lumber will mean the adoption of:

a. A definite plan of classification and nomenclature to be used in describing kinds, grades, and sizes of lumber.

b. A logical series of lumber grades based upon certain standard defects. These grades to be chosen in such a manner as to cover all species and kinds of lumber by definite basic rules. These basic rules are to be modified slightly by permitting or restricting other defects, if necessary, to meet variations due to use of product or nature of growth in tree.

c. Uniform sizes for all commercial grades and kinds of manufactured lumber.

All books of grading rules for lumber will follow the same general arrangement of descriptive matter.

The words, definitions, and trade terms used in these books will have the same meaning with each species of lumber.

Designers will soon learn the standard sizes and will know that these do not vary in the different species. Also, that a given grade of lumber is practically the same in all species, except for minor variations in defects which will be stated clearly in the grading rules for a given species.

Standard tables for use in designing structures can be prepared for architects and engineers, depending upon unit stresses only.

The industry will profit by removing the present elements of uncertainty in preparing lumber specifications, thus satisfying the consumer and making it easy for him to use wood properly. The adoption of definite standards will cause the designer to consider wood more favorably and thus create a greater demand. One of the best ways to meet competition is to make it easier for the consumer to buy.

FERRIS WHEEL OF PARIS TAKEN DOWN.

In the recent past there have been two worthwhile attractions in Paris for the tourists in search of big things, namely, the Eiffel Tower and the giant wheel. But today the latter, which has been proclaimed unsafe and a serious menace by the powers that be, is being taken down, piece by piece.

"La Grand Roue," as it is called, was completed in 1899 and opened to the public during the exposition of 1900. It measured 325 feet in diameter and was of remarkably light construction. Since then it has offered entertainment to tens of thousands of visitors to Paris, commanding, as it does, an excellent panorama of the city. By last October, however, the authorities decided that the wheel was no longer safe, and they stopped its operation. More recently the owners of the wheel, finding no further use for their property in its usual shape, decided to dismantle it and to convert the cars and steel and cables into spot cash. It is just as well perhaps, for Ferris wheels have long since outlived their usefulness.

—"Scientific American," Feb. 26, 1921.

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ON "GETTING BY"

Slang phrases come and go in much the same manner as do popular songs. When such expressions do remain in common speech, it is because they phrase an idea of constant occurrence to the public mind in a very forceful way. Such a phrase is the much used expression—"Getting By."

It is common to envy the man who "gets by" with his studies. There are business men who seem to "get by" on their "pull." Salesmen are said to "get by" on their "line."

The phrase is in daily use everywhere.

It first sprang into existence during the recent war. Labor was scarce. Men of little or no ability were in great demand.

The natural tendency of the worker was to obtain as much money for as little work as possible. From this tendency came the expression, and as the former has lasted, the latter has also stayed.

The appeal to "get by" is great, because results which otherwise seem far off appear easily obtainable. Success is made a simple thing, and no great effort is required to attain it.

Adherence to such a creed through life, however, will lead to ultimate indolence. It violates one of the foremost laws of science and of common sense—that of the Conservation of Energy. A man certainly cannot get any more out of an enterprise than he puts into it—and "getting by" implies that he can do just this.

"Getting by" leads to jealousy and bitterness. One sees the goals reached by those ahead of him without realizing the accompanying effort spent. Jealousy results.

"Getting by" leads one to misrepresent facts, for when one tries to advance without effort, a lie may seem to open the way more easily. The impulse is followed, and when the crisis comes, the man has not "got the goods," and failure results. Inevitably, then, the circumstances rather than the creed are blamed.

No truly great man ever "got by." Washington was one of the most conscientious workers known. Lincoln spent hours in study. Edison and Stienmetz are noted as much for their persistency as for their genius. Hoover obtained his reputation for clear thinking by constant practice and concentration.

Let no one be fooled by this catch phrase. It may make a strong appeal, but it is false. "Getting by" has caused the attitude that is responsible for much of our labor trouble today. It has ruined more than one promising business and can lead to no permanent good.

The creed which leads to all true and permanent success seems best stated by one of the ablest and most energetic Americans of all time. Theodore Roosevelt says:

"I wish to advocate, not the doctrine of ignoble ease, but the doctrine of the strenuous life—the life of toil and effort, of labor and strife; to uphold that highest form of success which comes, not to the man who desires mere easy peace, but to the man who does not shrink from danger, from hardship, or from bitter toil, and who out of these wins the splendid, ultimate triumph."

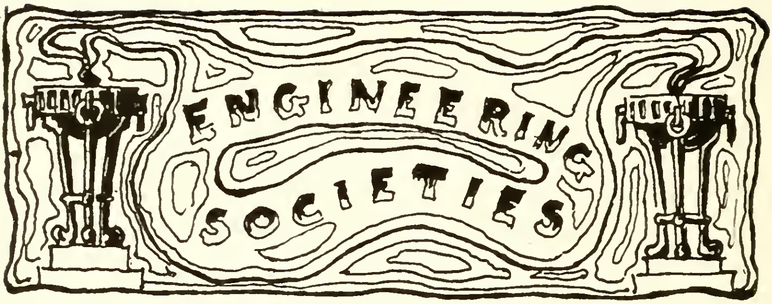
HOW DID YOU DIE?

Did you tackle that trouble that came your way
  With a resolute heart and cheerful?
Or hide your face from the light of day
  With a craven soul and fearful?
Oh, a trouble's a ton, or a trouble's an ounce,
  Or a trouble is what you make it,
And it isn't the fact that you're hurt that counts,
  But only how did you take it?

You are beaten to earth? Well, well, what's that?
  Come up with a smiling face.
It's nothing against you to fall down flat,
  But to lie there—that's disgrace.
The harder you're thrown, why the higher you bounce;
  Be proud of your blackened eye!
It isn't the fact that you're licked that counts;
  It's how did you fight—and why?

And though you be done to the death, what then?
  If you battled the best you could,
If you played your part in the world of men,
  Why, the Critic will call it good.
Death comes with a crawl, or comes with a pounce,
  And whether he's slow or spry,
It isn't the fact that you're dead that counts,
  But only how did you die?

—Impertinent Poems, by Edmund Vance Cooke.



THE ARMOUR INSTITUTEOF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Charles T. Walter.....................*President*
John P. Sanger..................*Vice-President*
Robt. W. Van Valzah...............*Treasurer*.
William A. Heitner..................*Secretary*

A general meeting of all the mechanical students was held in the Mission on January 12, 1921.

The program consisted of a motion picture film on "Car Motor Truck Axles." This film was purely educational, and proved very instructive.

An illustrated lecture was given by Mr. G. R. Read on "Diamond and Gold Mining in Africa." Mr. Read's lecture was entertaining and instructive, giving an insight not only of the operations of the mine, but also of the way in which the natives live in the Transvaal.

"A Summer Spent on an Ore Boat" was the topic discussed by Mr. Paul Rupprecht in which he described the methods in which ore is shipped and loaded at the various docks on the Great Lakes route. His account was so interesting that many expressed their desire to ship out on the Great Lakes during the Summer.

Other topics were: "The Manufacture of Condensed Milk," by Mr. H. E. Hagen, and "Drilling for Oil," by Mr. Mark Rumley.

Mr. Rumely explained many of the difficulties encountered in this work. He told of one instance when the rope snapped and the drill head was lost in the bottom of the bore. Since the tool could not be retrieved it was necessary to "shoot" the well. This meant that 2000 feet of casing had to be pulled up and a charge of nitroglycerine exploded at the bottom of the bore. The way in which

he explained this and other methods of procedure proved very interesting. His talk was entirely extemporaneous, since the time left was insufficient for the discussion of his original topic.

The annual "Smoker" was held in the Y. M. C. A. rooms at Armour, on February 25th. It was one of the BIG events on the A. S. M. E. schedule for 1921.

The program was arranged by Messrs. S. Webster, B. Wolgemuth and S. Barce, of the social committee, who supplied "eats" and "smokes" in abundance.

Professor George F. Gebhardt, who was the speaker of the evening, briefly outlined the object of the Society by calling attention to its value and application. He expressed regret for those freshmen and sophomores who did not avail themselves of this opportunity to become acquainted with the Faculty of the Mechanical Department and other members of this Society, since this was primarily the purpose of the Smoker.

Several other Professors were called upon to say a few words, and the way they responded showed their willingness to co-operate with the students—which is manifestly the true Armour spirit.

W. A. Heitner, Secretary.

ARMOUR INSTITUTE OF TECHNOLOGY BRANCH AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

R. C. Malwitz.................... ....*Chairman*
T. L. Albee...........................*Secretary*
W. W. Pearce.......................*Treasurer*

The A. I. E. E. Smoker originally planned for January 7, 1921, had to be postponed because it conflicted with other school activities. The postponement was announced at the meeting of January 6, but in spite of this disappointment, the talks and discussions at the meeting were heartily enjoyed.

Exams then approached with the end of the semester, and of course, interest was centered strongly on matters other than the A. I. E. E. It was necessary, therefore, to wait until the second semester was well under way before the next meeting could be called. On February 18, a regular meeting was held, and the Smoker arranged for the evening of February 25. At this meet-

ing, an instructive lecture on "Moving Picture Projectors and Their Accessories," was given by Robert P. Burns, and a talk on "Salesmanship in Engineering," by Fletcher E. Hayden.

The Smoker on the 25th was a complete success, in spite of the fact that the outside speakers failed to appear. Chairman Malwitz opened the festivities and was followed by Prof. Freeman who gave a long talk on "The Character of an Engineer." He explained the various systems of character judging used by several big companies in selecting men for engineering jobs, and he showed a few of the ways by which students can examine themselves, and work towards improvement in character.

After Professor Freeman's talk, the refreshments were served. "Smokes" were plentiful and good; and the "eats" were more than enjoyable. Music was furnished by Harry Kihlstrom and George Zahrobsky, with piano and violin. The meeting became a real "get-together" social affair, with card-playing, talking, and music, and was thoroughly enjoyed until the lights went out at 11:30.

Watch for the future "doings" of the A. I. E. E.

T. L. Albee, Secretaary.

ARMOUR BRANCH OF THE WESTERN SOCIETY OF ENGINEERS

R. M. Singer........................*President*
G. C. Kumbera..................*Vice-President*
G. W. Peterson......................*Treasurer*
A. Appelbaum ....*Secretary*

Attention should be called to the quality of the lectures presented to the society during 1920, which were especially successful due to the efforts of the President in procuring speakers of interest and ability.

At the last meeting December 8, 1920, Mr. Langdon Pearse, chief engineer of the Sanitary District of Chicago, gave a talk on the subject of "Sewage Treatment and Disposal." His discourse did not only include the problems of design and construction, but also the various difficulties that arise in financing a sewerage project. The speaker placed great stress on the necessity of diplomatic dealings with the "average" citizen who knows little and cares less about this matter so vital to his welfare. The meeting was brought to a close after a general discussion by the

members. Undoubtedly, Mr. Pearse's lecture was a benefit to every-one present, and we all hope he favors us again in the near future.

Since the last issue of the "Engineer," many names have been added to our membership list. At the present writing our total enrollment consists of sixty-three, including both active and participating members.

The next meeting will take place on March 2, 1921. The main business will be the election of officers for the next term. The required petitions for nomination are now being drawn up, and from all indications a spirited race is sure to ensue. The earnest co-operation of all concerned assures the progress of the society, and the results of the coming period will most probably be even more remarkable.

A. Appelbaum, Secretary.

ARMOUR RADIO ASSOCIATION

President .... E. A. Goodnow
Chief Operator .... H. I. Hultgren
Secretary .... Ralph Kenrick

The sixth regular meeting of the Association was held on January 5, 1921, in the Physics Lecture Room. This meeting was featured by a laboratory demonstration of the radio telephone. Mr. A. R. Mehrhof, in conjunction with Prof. Wilcox, set up a complete radio telephone transmitting and receiving station. The transmitter was of the vacuum tube type, employing grid circuit modulation. The results obtained were fairly satisfactory considering the fact that no antennæ was used. Mr. Mehrhof gave an illustrated lecture on "Methods of Modulation" with particular reference to modulation produced by the human voice. He explained that in general modulation is the impressing of one frequency upon another higher frequency. In the case of radio telephony he explained that the variable frequency of the human voice is impressed upon the much higher frequency produced by the oscillator circuit of the transmitter. The various circuits that can be used to produce this result were projected upon the screen, and explained in detail by the speaker. The circuit diagrams shown included arc sets, vacuum tube sets, and one circuit showed a method of using a high frequency alternator through

properly amplified field circuit control. The lively discussion which followed this talk was evidence of the interest shown by the members. The application of the magnetic amplifier of Dr. Alexanderson, in this connection was pointed out by Prof. Wilcox.

The next meeting of the Association was held on February 2, 1921, in the Radio Room in Chapin Hall. The Association was fortunate in securing a "Magnavox" loud speaking telephone for this meeting. The loud speaker was used in conjunction with a four step vacuum tube amplifier. Spark stations in the local district were received with a deafening roar capable of being heard all over the building. Wireless telephone music from an amateur station was received with sufficient intensity to be heard clearly anywhere in the room. An interesting thing noted was that with four steps of amplification the distortion of the music was almost negligible. Using the station's low power undamped wave transmitter (9YL) communication was carried on with several amateur stations in the vicinity.

Ralph Kenrick, Secretary.

DID YOU GET ONE?

Your last chance to secure a copy of the 1919-20 "Cycle." The Senior Class has reduced the price of the "Cycle," bound in green, black or tan leather, which formerly sold at $5.00 to $3.00. There are only a few copies on hand, so mail your remittance promptly to S. N. Havlick, care Armour Engineer.

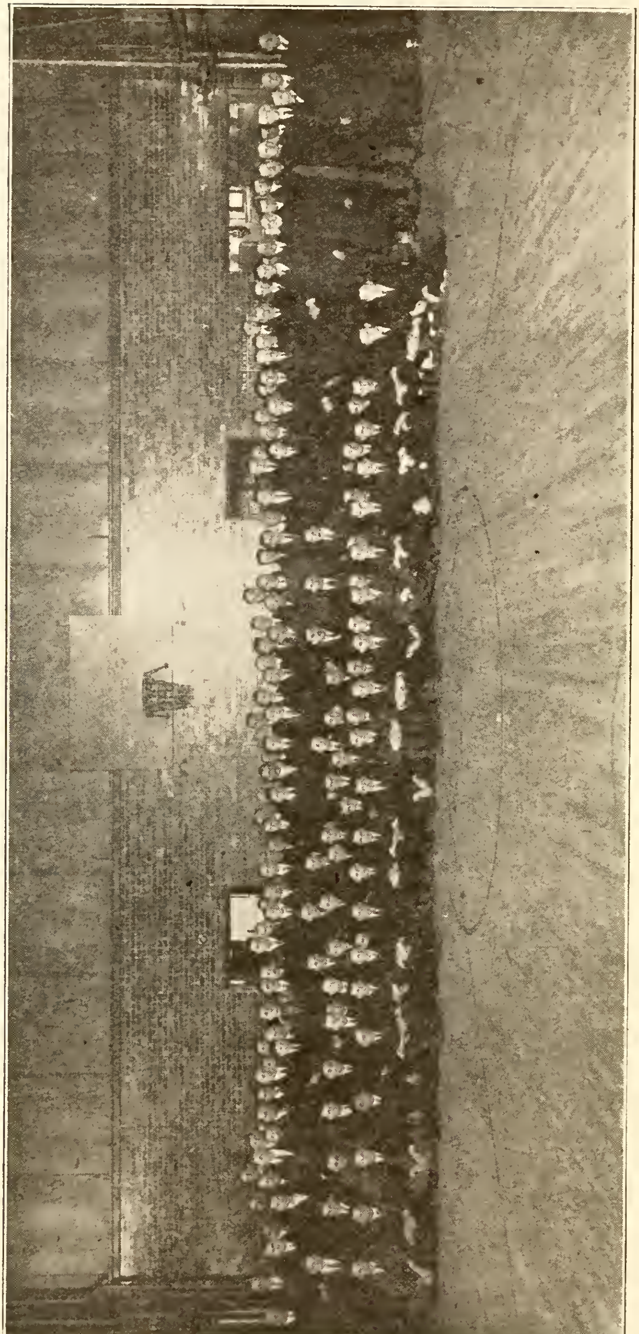
COLLEGE NOTES

THE VISIT OF THE SENIORS TO ARMOUR AND COMPANY

On Thursday, February 17, the entire Senior class and a large number of the professors of the Institute made what proved to be a very interesting and profitable trip through the Armour and Company plant at the Stockyards, at the invitation of Mr. Phillip D. Armour. The men met in the Armour and Company gymnasium at 8:15 in the morning where they were divided into groups according to their particular line of work. Each group was under the guidance of an expert in its line. Thus the Mechanical Engineers were under the direction of the Assistant Master Mechanic, the Chemicals were guided by a chemist, the Electricals by a man from the electrical department, and the Civil Engineers and the architects were in charge of a construction expert. This arrangement made it possible for each man to see that part of the plant which interested him most, and the plan worked out to perfection.

The entire group was first taken as a unit through the killing, skinning, and butchering departments, and the progress of the animals was followed from the stock pens straight through to the wholesale market. The most impressive thing about this part of the trip was the perfect co-ordination of all the units performing the work. Division of labor was here carried to the limit and each man had but a single operation to perform on the animal as it passed slowly by him hung from an overhead trolley. When it was realized that but 72 hours elapse between the time when the animal enters the plant and is ready for shipment, some idea of overall efficiency was gained.

After the trip through the main plant the groups divided, and each spent the rest of the morning inspecting that part of the plant which was of greatest interest to them. The Mechanical Engineers spent most of their time in the power plant and about the refrigeration machinery; the Chemicals visited the laboratories and the oleomargerine plant; and the Electricals and Civils each visited places of special interest to them. In each of these de-



partments the results of keen engineering analysis as applied to the particular problem of the packers were seen, but a detailed description of the devices would be impossible here.

At 12:30 the groups reassembled at the gymnasium where they were met by Mr. Armour and had their picture taken, a copy of which is shown here. The men then went to the lunch room in the main building where they were served a truly excellent dinner topped off by some genuine strawberry shortcake.

Mr. Philip Armour then gave a short talk on the relation of the Institute to Armour and Company. Mr. White, vice-president of the White Motor Truck Co., gave a very interesting discussion of the future of the truck industry. Mr. Noble spoke on the relation of the cattle raising industry to the stock yards, and Col. Evans, an Armour man of '12, gave some very graphic reminiscences of his college days. Dr. Gunsaulus concluded with a few of his usual apt remarks.

The men who went on the trip enjoyed a very profitable and interesting visit, and were very glad to hear that it is to be made an annual custom—the date to be between the birthdays of Lincoln and of Washington. All of the men are exceedingly grateful to Mr. Armour for his excellent hospitality and wish to thank him greatly.

LINCOLN'S AND WASHINGTON'S BIRTHDAYS.

Two very interesting assemblies were held during the month of February, one on Friday the 11th, in memory of Lincoln's birthday, and one on Tuesday the 22nd, in memory of Washington's birthday.

At the first of these President Gunsaulus delivered a very interesting lecture on Abraham Lincoln.

At the second Mr. Eugene Prussing, an eminent lawyer of Chicago, talked on "Washington as an Engineer." Mr. Prussing brought out clearly that while Washington was noted most for his ability as a soldier and as a statesman, he owed his success to that clear thought and ability to organize which everywhere characterize the successful engineer. Some incidents of the personal life of Washington were told which showed that even at an early age, he was trained in the engineering point of view.

BASKETBALL

Since the last issue of the Armour Engineer the basketball team has played a number of interesting games, the first of which was with Notre Dame in the Armour gymnasium. This game was one of the hardest fought of the season due to the strong defense of the opposing team which consisted of football men. Coughlin, Kiley and Anderson were All American football material. The visitors came to Armour expecting an easy victory since they had a clean slate for the entire season. Their attitude changed, however, when the Armour team started the scoring with a four point lead. Mehre, center for Notre Dame, put his team in the lead with a series of long clean shots. Schumacher made five baskets for Armour while Witashkis and Havlick each made three. The game was the best attended one of the season and many expectant visitors were turned away due to the limited capacity of the gymnasium.

The Armour team defeated the Chicago Technical College by superior pass work in an easy game on the Tech floor by a score of 31 to 9. Sippel, Witashkis and Schumacher made the greater number of points for Armour.

The Lake Forest team was the next to meet defeat by the Armour quintet. The game was played at Lake Forest and was the slowest game of the season due to the strict refereeing. The Lake Forest team had a lead at the half of 19 to 12, but the Tech players came back strong in the second half with close guarding and snappy passes and defeated their opponents by the narrow margin of 24 to 25.

The Institute players made a trip to Rock Island, Illinois, and played Augustana College of that city. The Augustana players gained an early lead which they held throughout the entire game, Bengston being their leading scoring factor. Havlick led the Armour scorers with four baskets.

The Tech players next visited the American College of Physical Education of Chicago and obtained a victory by a score of 25 to 20. The Institute team was handicapped by the loss of Schumacher's assistance because of an injury to his side in the Augustana game. Havlick added the bulk to the Tech score with seven baskets. The score at the half was 18 to 22 in Armour's favor. During the second half both teams tightened up on their defense, and as a consequence only one basket was made by each team during the second period.

Lake Forest came to Armour to take a victory to avenge their defeat on their home floor but were again beaten by the Engineers. The game was a hard fought one, the score at the half being 14 to 15 with the margin belonging to Armour. By the end of the second half the Tech players had increased their score by a greater proportion than their opponents had, the final score being 29 to 24. Schumacher featured for Armour with eight baskets.

When the Armour players journeyed to South Bend, Indiana, to play the Notre Dame quintet a return game they encountered the unexpected and unprepared for—a dirt floor. As a result the team met the greatest defeat of the season, being unable to pivot, stop or turn quickly without cleats on their shoes. The Notre Dame team was disappointed as they had expected a very hard game after their experience in the Armour gymnasium.

Elmhurst College team came to Armour and were defeated 28 to 14. Schumacker made six baskets for Armour, Havlick three and Kuehn and Witashkis each two. Heckmann made the greater number of baskets for the visitors. No baskets were made by Armour on free throws while the visitors added four points to their score in this manner.

The Tech team made it's final trip of the season to Southern Illinois, where they played against the Illinois Wesleyan and James Millikin Universities at Bloomington and Decatur, respectively. These teams are rated among the strongest in the state and expected easy victories. On February 21st the Armour team was beaten by Illinois Wesleyan in a close and hard fought game. The score at the half was 14 to 12 in Illinois favor, the final score being 31 to 40. Schumacker made six baskekts for Armour, Havlick and Witashkis each adding three more. At no time in the game did the Wesleyan team have a safe lead.

On February 22nd, the night following the Wesleyan game, the Institute team defeated the James Millikin University, in a strenuous battle on their home floor. The game was characterized by the close guarding of both sides. The Armour team gained the lead in the first half, which ended in their favor with a score of 10 to 1. It was thirty-two minutes before the Milliken team were able to score a basket, though they were the first to score during the game. Each team played a half without scoring a basket. The final score was 8 to 12. James Millikin has defeated the University of Illinois and Illinois Wesleyan and many other of the strong teams in the state, so that this victory for the

Armour team was one to be proud of. The Institute team was greatly handicapped on this trip due to the absence of Ahlbeck, the Tech's star forward, due to injuries.

During the game the Armour team was supported by a lone rooter who proved to be a very efficient one, namely, Mr. Donald Willard, an Alumnus from '05. At Decatur the team was the guest of Mr. Willard at the Oriental Inn, after which he took the players on an inspection trip to the Decatur Malleable Iron Co., of which he is president. The team's final trip proved to be the most successful and enjoyable of the season.

The final game of the 1920-21 season was played in the Armour gymnasium against the Augustana College of Rock Island. The visitors came fully intending to defeat the Armour team, as they had done for three successive games in the past. This was one of the hardest fought and most interesting games of the season, and at the half appeared to be a defeat for the Engineers, the score being 23 to 14 in favor of the visitors. In the second period the Tech players tightened up on their guarding and increased their score by spectacular basket shooting. With four minutes to play the score was tied. During the remainder of the game the Tech players added one more basket to their credit, making them victors by a 33 to 31 score.

After the game a meeting was held in which the team elected Don Rutishauser next year's Captain.

Much credit is due Professor Schommer for the success of the team during the latter part of the season. He took charge of the coaching after W. E. Johnson's resignation was requested, and was able to carry the team over the most difficult part of the schedule and obtain five victories out of seven games.

BASEBALL

The baseball season, 1921, was ushered in on March first. Baseball practice has already begun under the direction of Coach J. Leo Walsh, a first baseman on the Bloomington Champion team, 1920, and under contract to play in the Three-Eye League upon the completion of his work with the Armour Institute of Technology on June first.

The new coach opened up practice by giving the candidates a line on the proper methods of bunting, and batting, as well as the knack of picking up grounders. A host of new material appeared

to cast their lot for places on the college team. It is Walsh's opinion that a strong team may be formed out of the 35 players that are now undergoing the tests outlined for them.

The Institute is in great need of a pitching staff. About a half dozen candidates have taken to the mound. The only nucleus left around which to build a strong pitching staff is made up of Van Dyke, Gilbertson and Desmond. Infielders who look good are Tener, Rutishauser, Rowe, Kuehn, Schumacher, Sippel, Hardwicke, Bradley, Latta, Rupprecht, Anderson, Stoker, Parkin, Spaid, Andrzelcyk and others.

It is anticipated at this time that when the Board of Athletic Control meets, they will adopt the following schedule for the season 1921:

Elmhurst College	at Armour	Sat.	April 2
Beloit College	at Beloit	Mon.	April 4
Northwestern University	at Evanston	Sat.	April 9
University of Chicago	at Stagg Field	Tues.	April 12
Augustana College	at Armour	Fri.	April 15
Concordia Teachers College	at Armour	Tues.	April 19
Bradley Polytechnic Institute	at Peoria	Wed.	April 27
Lake Forest College	at Armour	Sat.	April 30
Beloit College	at Armour	Tues.	May 3
Bradley Polytechnic Institute	at Armour	Fri.	May 6
Augustana College	at Rock Is'nd	Sat.	May 7
Elmhurst College	at Elmhurst	Wed.	May 11
Lake Forest College	at Lake Forest	Mon.	May 16
Valparaiso University	at Armour	Fri.	May 20
Concordia Teachers College	at Oak Park	Sat.	May 21
Valparaiso University	at Valparaiso	Mon.	May 23
De Pauw University	at Greencastle	Tues.	May 24

What is the most sought attribute of a baseball team?

That question has been answered and discussed by many coaches. Some say that the ability to have freeness of motion is the greatest asset. Others assert that to be able to throw quickly and accurately is the difference between victory and defeat. Still others contend that teamwork wins every contest.

It must be conceded that no team would be a success without the accomplishments named, still the predominating factor governing a coach's actions as he starts his players along the training route is to round them into condition and keep them

that way. By condition is meant that state of physical perfection that will keep a team fresh and fast to the final inning, and will keep it at the same point of alertness the last inning as in the opening one.

Many a game has been won or lost just because the players were or were not able to stand the gaff. In fact some coaches go so far as to say that every game that was ever won was due to the superiority of the winner's condition.

Although that statement is rather broad and will, no doubt, be disputed by many authorities, still it is true that the team that goes into the game in good physical condition has a great advantage over the opponents that start to lag after the seventh inning.

The more seasoned a team is, the greater are their chances for winning.

SENIOR CHEMICAL THESES

The Estimation of Benzene in Admixture with Parafin Hydrocarbon.—Raymond S. Scherger.

The Formation and Properties of Benzene Meta Di-sulphonic Acid.—Cornelius Sippel, Jr., and Harry W. Ahlbeck.

The Study of the Formation of Aluminum Nitride.—Eugene B. Rudd and Lawrence L. Veit.

Zinc Nitride, Its Formation, Properties and Alloys.—William J. Savoye and Alfred R. Edwards.

Heat Transmission in Condenser Coils.—Walter J. Anderson and Lyman D. Judson.

The Study of the Formation of Chromates and Di-chromates.—Hilton Kaplon and Herman M. Schiffman.

The Absorption of Carbon Dioxide from Gas Mixtures.—Aaron Pashkow.

Electrostatic Precipitation of Soaps from Oils.—Mynhart O. Brueckner and George M. Dowse.

Reduction of Ortho-Nitro-Benzoic Acid.—Emil F. Winter and Emil W. Pfafflin.

SENIOR ELECTRICAL THESES

F. A. Anderson, F. E. Hayden: A Partial Illumination Survey of the City of Chicago.

L. S. Bloom, G. J. Zahrobsky: The Design, Construction, and Test of a Slip Meter.

R. O. Klenze, C. A. Grabendike: The Effect of Spark Frequency Upon the Ignition Range of Explosive Vapor Mixtures.

M. J. Grill, H. F. Schreiber: The Design, Construction, and Test of an Electro-Magnetic Dynamometer.

H. C. Kihlstrom, J. J. O'Rourke: The Design of a 20,000 K. V. A. Power Plant.

R. J. Grant: A Cost Estimate of a 20,000 K. V. A. Power Plant.

T. L. Albee, R. C. Malwitz: The Relative Cost of Operating Steam and Electric Locomotives for Switching Purposes on the St. Paul R. R. Industry Tracks.

W. W. Pearce, D. L. Rosendal: The Design, Construction, and Test of a Vacuum Tube Radio Telephone.

R. Knotek, J. Newman: The Thermal Control of Electric Heating Appliances.

D. K. Muramoto: A Study of Commercial Illumination.

ALUMNI NOTES

A LOYAL ALUMNUS

During the basketball team's recent trip to Decatur, Illinois, where they played against the James Millikin University, the following incident occurred: It was between the halves and the team had gone to the dressing rooms to rest. The score was 10 to 1 in favor of Armour. When the reserve players who had been sitting on the bench came down they said "Keep it up fellows, you are playing a wonderful game. The whole grandstand is with you, rooting against their own men." Later it was discovered that Mr. Donald Willard, '05, was the source of all the cheering.

After the game Mr. File, a Millikin Alumnus, Mr. N. Peterson, an Armour instructor who managed the team, and the team were the guests of Mr. Willard for dinner at the Oriental Inn. It was a merry group that compared the college days of '05 with those of '21. And what could be more pleasing to a basketball player than an elaborate dinner after a hard fought game?

After dinner Mr. Willard called up the Decatur Malleable Iron Co., of which he is president, and had the night watchman illuminate the plant. The entire party was then driven in Mr. Willard's and Mr. File's automobiles to the Decatur Malleable Iron Co., and an inspection trip through every part of the industry was conducted by Mr. Willard who explained each process in detail. This trip proved a very instructive and enjoyable one. Features which impressed all were the cleanliness of the plant, the modern equipment and the high test results of the products. Another point of interest was that Mr. Willard has in daily use the slide rule and set of drawing instruments which he purchased when he entered the Academy of the Armour Institute.

The team wishes to express its appreciation to Mr. Willard for making the Decatur trip the most enjoyable trip of the season.

NEW ADDRESSES

James G. Shakman, '14, has left Chicago to take a position in Pittsburgh with the International Filter Co.

George W. Smith, '06, is now connected with the Central Texas Ice and Light Co., Marlen, Texas.

R. H. Sarle, '17, who has been doing such satisfactory work with the Cutler Hammer Co., has moved to the Allis-Chalmers Mfg. Co., of Milwaukee. He is to be in the Hydraulic Turbine Dept.

I. R. Wishnick, '14, is now president of the Wishnick-Tumpeer Chemical Co., Chicago.

Milton Foskett Daniels, '11, for some time past with the Home Insurance Co. of Chicago, has been transferred to their Portland, Oregon, office.

Leroy J. Enzler, '16, is now in St. Louis with the Goodman Mfg. Co. He was formerly located in the engineering department of the same firm in Cincinnati.

Eugene S. Harman, '15, and Wm. Dady, '19, are both with the Wisconsin Steel Co. in Chicago.

OBITUARY.

Frank Edward Wernick, 1910, mechanical engineer, Syracuse, N. Y.

ALUMNI NOTES

The Armour Alumni dance was held in the Red Room of the La Salle Hotel, Friday evening, February 4th, 1921. The music was inspiring, the floor was in excellent condition, the dancers were all in fine spirits and a wonderful time was certainly had by everyone present. The only unfortunate thing about these alumni gatherings is that so many of our former graduates do not realize what good times they are missing when they fail to turn out for them. If you missed this dance just make up your mind right now to surely be present at the Spring Banquet, which will be held some time during May, the exact date and place to be determined later. Come once and you will certainly come again.

A NEW USE OF THE ARMOUR BULLETIN

A unique use of the Bulletins of the Armour Institute of Technology was mentioned by an alumnus the other day. He said that since graduation he kept a complete file of them and used them in looking up the references and qualifications of Armour men who were seeking employment under him.

If the address was 33 Michigan Avenue, and no business connection was mentioned, he considered that it was evident that the

man had forgoten his Alma Mater, or was too careless and slipshod to send in his changes of address and the names of his employers.

It also showed that mail sent by the Alumni Association or by the Institute was being delivered and that he was too "busy" to fill in the return postal cards. "Location unknown," of course, gave absolutely no information and would give perhaps a worse impression than an old and evidently incorrect address.

Where a bona fide address and a real business was given, and if in this case the information, when compared with the information furnished by the applicant in his letter, was evidently old, the impression on the mind of the employer left a great many things to be desired.

If, however, the changes of business and changes of address had been kept up to date, as indicated yearly by the copies of the bulletins, and where these facts agreed with the facts as furnished by the applicant, the veracity, the thoughtfulness and thoroughness, as well as the technical qualifications, were well indicated.

Nothing need be said of the few cases where references and the facts contained in the year book do not agree.

(J. C. P., 1905.)

NOTE—Better keep the Institute posted as to your whereabouts and your business connections. And, an occasional news item under the head of Alumni Notes won't hurt you any.

BOOK NOTES

The following books have been added to the Library recently to be used as tools in the Departments of:

MECHANICAL ENGINEERING

Hatt & Scofield. Laboratory manual of testing materials. Gives methods of tests, specificatioins and related data.

Hibbard, H. D. Manufacture and uses of alloy steels. Presents in a concise manner information of present value, relating to the manufacture and uses of the various commercial alloy steels.

Hultgren, Axel. Metallographic study on tungsten steels. The subject is divided into two sections, first, the transformations of tungsten steels during different heat treatments and the structures thereby formed, and, second, carbides in tungsten steels.

Moore, H. Liquid fuels for internal combustion engines. The author "has attempted briefly to explain the chemical differences which exist among liquid fuels." A glossary of trade names for petroleum products is included.

Thomsen, T. C. The practice of lubrication. An engineering treatise on the origin, nature and testing of lubricants and on their selection, application and use.

ELECTRICAL ENGINEERING

Croft, Terrell. Wiring for light and power. Explains clearly, in simple language, how to install wiring and apparatus for practically all services to meet the requirements of the National Electrical Code.

Fish, F. A. Fundamental principles of electric and magnetic circuits. An introduction to the study of electric power machinery and transmission.

Gandy, T. S. Direct-current motor and generator troubles. "Explains sources of trouble when standard types of motors will not run, and analyzes points on the selection, care and repair of machinery by the operator."

Lamme, B. G. Electrical engineering papers. This volume is a collection of the author's more important engineering papers presented before various technical societies and published in engineering journals.

Peek, F. W. Dielectric phenomena in high voltage engineering. "This book covers the properties of gaseous, liquid and solid insulations, and methods of utilizing these properties to the best advantage in the practical problems of high voltage engineering.

CIVIL ENGINEERING

Kean, F. J. A critical survey of current practice with special reference to the balancing of inerita forces.

Lanchester, F. W. The flying-machine from an engineering standpoint. A series of lectures by a member of the British Advisory Committee for Aeronautics on aerodynamics and airplane construction.

Thompson, G. P. Applied aerodynamics. An up-to-date presentation of the existing state of aeronautical science.

Watts, H. C. Design of screw propellors. A record of the methods used by the author for the design of screw propellors for actual service in the field during the war.

Wilson, E. R. Aeronautics. As treated here the two main divisions of the subject are Rigid Mechanics and Fluid Dynamics, both of which the writer considers fundamental in aeronautical engineering.

CHEMICAL ENGINEERING

Giua, M. & Giua-Lollini, Clara. Chemical combination among metals. The chemistry of metals has been largely studied by means of thermal analysis.

Henderson, G. C. Catalysis in industrial chemistry. An illustrated record of over 200 applications of catalysis in the processes of industrial chemistry, compiled from various sources.

Rodenhauser, I. W. and others. Electric furnaces in the iron and steel industry. A book which thoroughly describes electric furnaces designed solely for the iron and steel industry.

Sutermeister, Edwin. Chemistry of pulp and paper making. The author's purpose is to assist the young technical man, who has a fair knowledge of the elements of chemistry, to understand the chemical processes involved in the manufacture of pulp and paper.

Watson, E. R. Colour in relation to chemical constitution. The subject matter of this book will be valuable to students on account of its scientific interest and its practical utility.

PHYSICS

Crehore, A. C. The Atom. An original contribution to the atomic theory and not a review or fresh presentation of current theories. The book contains also a readable account of the author's equation of gravitation.

Crowther, J. A. Ions, electrons and ionizing radiations. "An endeavor to bring the development of the last quarter of a century to the comprehension of the student equipped with a fair knowledge of the other branches of physics and of mathematics through the calculus."

Einstein, Albert. Relativity. "The discoverer's own explanation of relativity is written, as far as possible, to be understood by persons with college entrance equipment."

Humphreys, W. J. Physics of the Air. An account, reprinted from the Journal of the Franklin Institute, of the "physical phenomena of the earth's atmosphere."

Schlick, Moritz. Space and time in contemporary physics. An introduction to the theory of relativity and gravitation which gives an explanation of Einstein's important discoveries.

OF GENERAL INTEREST

Edman, Irwin. Hunman traits and their social significance. "Throughout the long process of civilization two factors have remained constant," says the author, "nature and human nature." This book is a thorough discussion of the second factor.

Fisk, H. E. Dominion of Canada. An account of our neighbor' government finances, resources, trade and manufacture.

Hawkins, N. A. Selling Process. In his article on Salesmanship in the November issue of the Armour Engineer Mr. Coffeen refers to this as "one of the most helpful first books on this general subject."

Horton, C. M. Opportunities in Engineering. These essays of popular interest are certain to furnish their readers with enthusiasm for a "wonderful profession" which the author considers "a force fraught with stupendous possibilities." The author continues: "Thus it will be seen that engineering is a distinctive and important profession, for the reason that engineers serve humanity at every practical turn." He also refers to the tremendous power which engineers wield in world affairs."

Hurley, E. N. New Merchant Marine. The former chairman of the United States Shipping Board tells in this book how the

problem of supplying ships for war demands was met, and discusses the future of the American Merchant Marine, foreign fields of commerce and related topics.

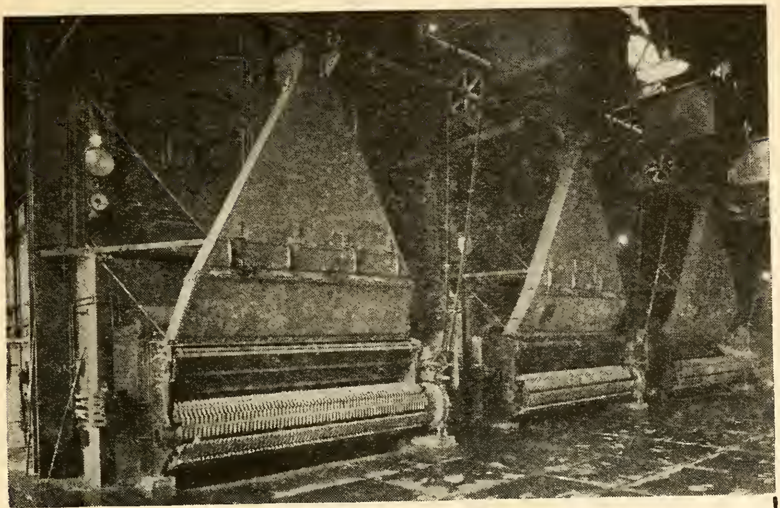
Kennard,. J. S. Goldini and the Venice of his Time. The biography of an Italian playwright of the eighteenth century followed by a description of his realistic comedies of Venetian life and manners.

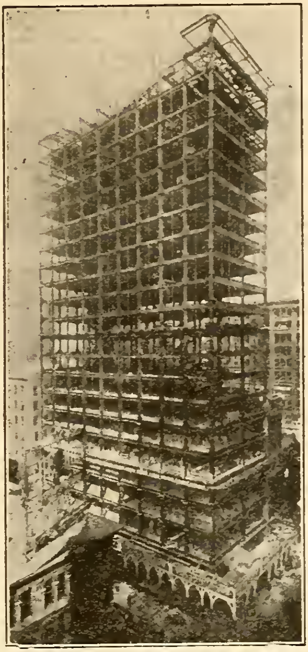
Pepper, C. M. The life and times of Henry Gassaway Davis, 1823-1916. His biographer tells of his pioneer railway days, his senatorship, his career as a railway builder, including the Pan-American Railway, his nomination as Vice-President, and his personal characteristics.

Vail, T. N. View on public questions. This collection of the writings and addresses of the President of the-American Telephone and Telegraphy Company from 1907 to 1920 will be of interest to students of the economic and industrial development of our country.

Beblen, T. B. Place of science in modern civilization. This carefully selected series of papers published in economic journals during the past twenty years sums up the author's economic theories.

ALPHABETICAL INDEX OF ADVERTISERS.





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Business Manager.

Sworn to and subscribed before me this 14th day of March, 1921.

GEORGE S. ALLISON,
Notary Public.

Chicago, March 14, 1921.
(Notary Seal)

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May, 1921

The Armour Engineer

VOLUME XII. MAY, 1921. No. 4

FEATURES OF THE NEW FULTON MARKET COLD STORAGE WAREHOUSE

By Lawrence L. Edlund, '16

The new Fulton Market cold storage warehouse which has just recently been put into operation in Chicago is one of the most modern structures of its kind in the country, and when the second section is built it will be one of the largest as well. The plant is located in the block bounded by Morgan, Fulton and Carpenter Streets and the C. M. & St. P. right-of-way, and is in the heart of the district which is destined to replace our present South Water Street produce market. Its location is therefore admirably suited to the business to which the company will cater: namely, the storage of fruits, eggs, butter, poultry and other perishable food products of a seasonable nature. Because of its recent construction and the numerous unusual features incorporated in its design, the plant is one which should be of interest to engineers.

The design of a cold storage warehouse such as this one, from the first preliminary studies to the completed plans, or perhaps better said, until the building is erected and in operation, is a long story, although it might not be an altogether boresome one. It would be considerably beyond the limits of this writing, however, to attempt anything so lengthy and therefore it will be confined to a general description of some of the principal features of the plant, followed by a more detailed discussion of some of those matters which will be of particular interest to mechanical engineers.

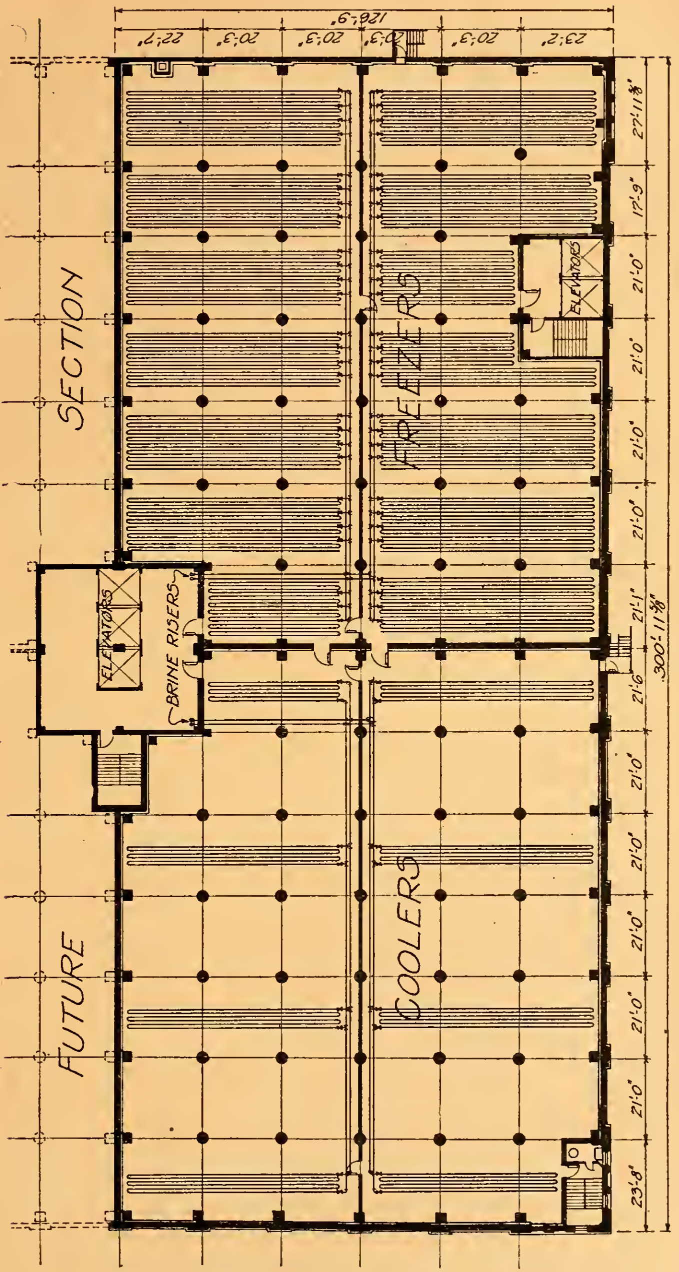
THE BUILDING STRUCTURE

The plant is located on a full city block. The present building occupies the east half of the block and the intention is to build the other half at a later date. The present building contains the general office and the engine room, in the laying out of which sufficient space has been provided to take care of all the additional

machinery which will need to be added when the other section is built.

The building consists of ten stories and a basement. In plan it is approximately 125 by 300 feet. The stories are all twelve feet from floor to floor, except the first, which measures 14 feet 9 inches, and the north half of the basement containing the engine room, which is eighteen feet high. The net area of refrigerated rooms is about 335,000 square feet and the net volume of this space (without deducting columns) is 3,800,000 cubic feet. The gross volume of the building is 5,472,000 cubic feet. When the second section has been completed the refrigerated area will be increased to 695,000 square feet, and the volumes to 7,900,000 and 10,500,000 cubic feet respectively. If the floors are loaded not to exceed the live load used in the design, the combined capacity of the finished plant will be in round numbers 150 million pounds.

The building is of reinforced concrete throughout and thoroughly fireproof. In order to obtain satisfactory foundations to carry the tremendous column loads from a building of this height and floor capacity, it was necessary to use caissons extended to


126'-9"
22'-7"
20'-3"
20'-3"
20'-3"
20'-3"
23'-2"
FUTURE
SECTION
FREEZERS
COOLERS
ELEVATORS
ELEVATORS
BRINE RISERS
300'-11⅝"

bed rock. This was reached at an elevation of about 97 feet below city datum or 112 feet below street grade.

The floors are of flat-slab design with bays 21′ 0″ by 20′ 3″, and all columns from the fifth floor line up are spirally reinforced. Below this line the interior columns have been made of structural steel, encased in concrete. This feature was resorted to in order to reduce the column diameters to a reasonable size in the lower stories. Had spiral columns been employed throughout, those in the basement and first floor might have exceeded forty-eight inches in diameter. Such large columns would very materially reduce the net volumne available for the storage of goods. As it is, the concrete-encased steel columns are everywhere 22 inches and the largest interior spiral columns do not exceed 30 inches.

Insulation against the outside temperature is secured by means of pure compressed corkboard which completely envelopes the refrigerated portions of the building. It is evident that in order to have this cork insulation complete and unbroken, the building must consist of an interior structure and an exterior brick enclosure separated from it by a distance equal to the thickness of the cork. Quite often this exterior wall is self-supporting, of the necessary thickness for its height, and anchored by suitable means to the interior building structure at each column. The Chicago building department is not satisfied with this construction, however, but requires that this outside wall be supported on a separate framework of reinforced concrete columns and spandrel beams. This is the construction at Fulton Market. There is a clear space of five or seven inches (to admit four and six inches of cork respectively) separating the inside and outside structures. These are tied together by means of single bar anchors located at each column head of the interior framing. With the exception of these few ties the cold rooms are completely and effectively insured from the outside. All doors to refrigerated space are of the latest design of cold storage door, having the same insulating qualities as the walls in which they are hung. The roof is of course also insulated with corkboard and has in addition an average covering of two feet of dry cinders to give proper pitch to the 2-inch concrete slab supporting the composition roofing.

The cut, Figure 1, shows the south and east elevations when the building was nearly completed. It also indicates the extent

of the large loading dock for teams and trucks. This dock is 146 feet long. The building is provided with three private switch tracks, two of which are within the building and enter at the opening shown at the extreme right in the picture. These will be extended when the future addition is built and will enable the placing of 18 cars at a time. Ample loading and unloading facilities are very essential to this business because of its seasonal nature, which means that the stored products are brought in within comparatively short periods: eggs in the spring, butter during the summer months, poultry and apples in the fall, etc.

The rapid and satisfactory handling of big quantities of these products requires large, speedy elevators conveniently located with reference to the loading platforms. The typical floor plan shown in Figure 2, indicates that there are five elevators and shows their location with reference to the rooms. On the first floor, they connect directly by means of wide passageways with the railroad and wagon platforms. The elevators are of the electric over-head traction type and travel at 175 feet a minute with a capacity load of 3000 pounds.

THE REFRIGERATING SYSTEM

The refrigeration of all cold rooms is done by means of the brine circulating system. There are numerous reasons why it is more desirable to use brine than the direct expansion of ammonia in a plant of this kind. Chief among these may be mentioned greater safety, avoidance of all ammonia leaks and consequent avoidance of odors in the rooms, compactness of the necessary ammonia piping, as this is entirely confined to the engine room, comparative ease of control, and lastly, the greater inertia of the cooling system which will permit of the compressors being shut down for many hours while the brine circulation is continued with only a very slow rise in the brine temperature.

The temperatures which will be maintained in this plant run from five degrees below to forty degrees above zero Fahrenheit. This is quite a wide range for a brine system. At times when both coolers and freezers are to be served, brine is used in the coolers and direct-expansion ammonia in the freezers. In plants having only direct-expansion ammonia it is necessary either to operate two compressors at different back pressures corresponding to the temperatures which are to be carried, or else a double-

acting compessor must be used and so piped that the two ends of the cylinder may be operated at the required different back pressures. The use of a single-temperature brine system is far simpler than any of these and has in addition all the advantages above mentioned. This is the system in use at Fulton Market. As it is desirable to have a difference of at least ten degrees between the brine in the pipes and the air of the room, and as the lowest temperature desired is five degrees below zero, the brine is circulated at —15 deg. fahr. Such a low temperature requires the use of calcium chloride brine and to be safe against freezing this is made with a specific gravity of 1.25.

The brine is cooled by means of three "Vogt" horizontal multi-pass coolers. These are 50 inches in diameter and 18 feet long and are rated at 125 tons of refrigeration when operated with —20 deg. fahr. brine. The pumps handling the brine are two "Hill" centrifugals of 1500 g. p. m. capacity each against a 50-foot head.

In a brine system of this size, it is necessary to make provision for surges in the lines and for expansion and contraction of the body of brine circulated. This has been accomplished by installing a surge tank at the highest point of the system. The brine supply risers decrease as they go up, but the returns riser begins with the lowest coils and increases in size going up and finally discharges into the surge tank. The drain from this tank then goes down to the engine room and constitutes the suction to the pumps. These then discharge into the coolers and from thence the brine travels up to the house. It will be noted that the brine system is a balanced one and that the pumping head consists simply of the friction through the coolers, heater and coil plus a very small lift. This accounts for the low-head pumps used. For purposes of charging the system and making up losses, a low-capacity high-head piston pump has been installed.

In the proportioning of the pipe coils for the various rooms, the customary ratios have been used except that in the coolers allowance has been made for the unusually low temperature of the refrigerant. Variations have also been made in cases of unusual exposures, etc. All pipe coils are of 2-inch standard wrought steel pipe. The average ratio on the cooler side is one lineal foot of pipe to 27.2 cubic feet of space and in the freezers the ratio is 1 to 7.9. The coils are made up in groups, no single

pair of supply and return valves handling more than 300 lineal feet of pipes. They are hung on the ceilings and vary from a single layer to three deep. In the coolers they are located above the aisles in order to permit the use of the full story height for the piling of goods.

The ammonia part of the refrigerating system is very compact and consists of the compressors, condensers, traps, etc. Two compressors have been installed and space is provided for two more in the future. These are "Ball" two-stage compressors having 28 x 42 inch low-pressure cylinders and 16 x 42 inch high-pressure cylinders. The suction to the L. P. cylinder will be 0 lb. and the reservoir in the line between the two cylinders is intended to be kept at 50 lb. The reservoir is provided with a pipe coil and all liquid coming from the receiver is passed through this coil in order to lower its temperature to a point approximating the expansion temperature in the brine coolers. This is a feature of efficiency in operation and it may or may not be employed as the operator chooses.

The ammonia condensers are also located in the engine room and are of the double-pipe type. They consist of 32 stands 12 pipes high and 21 feet long. The water for these is taken from the city mains and is recirculated, being pumped up to a "Roder" cooling tower located on the roof. This tower will cool the water down to within four degrees of the wet bulb temperature when the dry bulb thermometer is at 80 or above, and with an evaporation loss not greater than 5 per cent of the total circulated. The tower is specially constructed to avoid loss by spraying, being located as it is and subjected at times to very high wind velocities.

ELECTRICAL MACHINERY

The entire plant is electrically operated and is served from the 12,000 volt underground feeders of the Commonwealth-Edison Co. A high-tension switch room and transformer vault are located adacent to the engine room and contain 3-500 Kva. water-cooled transformers and a 50 Kva. lighting transformer. All power is 440 volts, 60 cycle, three-phase, and it is used on all the motors throughout the plant. The lighting is Edison single-phase three wire. The switch-board is in the engine room adjacent to the transformer vault and is complete with oil switches, relays, meters, etc.

The synchronous-motor drive of the ammonia compressors is of special interest because this is the only plant in the country in which this type of motors is used direct-connected to ammonia compressors of this size and capacity and under similar conditions. Each compressor is driven by a 600 HP, 80 RPM, 60 cycle, 3-phase, General Electric synchronous motor. The motors are provided with 18,000 pound flywheels to assist the flywheel moment of the motor rotor and relieve the supply line of excessive current pulsations which are characteristic in compressor drives. These motors are remote-control operated from duplicate sets of buttons located on the main switchboad and on motor starting panels at each machine. The oil switches are all solenoid operated and all motors are provided with no-voltage and overload relays giving them full protection. There are also two 50 KW synchronous motor driven exciter sets furnishing direct current for the fields of the large motors.

MISCELLANEOUS OTHER EQUIPMENT

Although the building structure is of itself fireproof, the goods to be stored are not and in order to secure the best insurance rate, the plant is equipped throughout with automatic sprinklers. A rather unusual feature of this installation is the location of the dry valves on the various upper floors rather than all together in the lower story as is generally done. There are two risers, one for each section of the building, and two floors of a section are on one and the same dry valve. The sources of water supply consist of two 20,000 gallon storage tanks located in the penthouse above the central elevator tower and a 1000 G.P.M. fire pump in the engine room.

Heat for the offices, sampling rooms, engine room and stairwells is supplied by a vacuum system. The boiler room is located to the north of the engine room and is equipped with a 7500 sq. ft. Kewanee firebox boiler and the necessary vacuum pumping equipment. The chimney for the heating boiler extends up through the building and out above the roof. In doing so, it passes through freezers practically all the way and special care had to be employed to secure the best insulation possible and also allow room for vertical movement of the stack, due to expansion and contraction.

Hot water is supplied to toilet and wash rooms from two "Ruud" instantaneous gas heaters.

All steam mains are insulated as are the brine risers wherever these run through unrefrigerated space. The brine coolers and all brine piping and ammonia suction lines are insulated with cork pipe covering.

The plant has at this writing been in operation several months, and although it has not yet been run at capacity, the indications are that it will be a very economical plant to handle. The synchronous motors are giving excellent performance, proving the wisdom of the selection of this type of drive. The fact that it enables the entire plant to operate at unity power factor makes it a very desirable customer of the electric service company and also gives it preferred rates which are very much worth while, as the power bills are a very large item in the operating expenses.

The entire plant and refrigerating system was designed by Gardner & Lindberg, Architects and Engineers, Chicago.

ATTACKING THE SNOW PROBLEM

The New York State Bureau of Municipal Information has sought reports from American cities according to the February issue of the "American City," on the method and kind of apparatus used for snow removal, in order to make available to municipal officials complete and up-to-date information. This is important because of the necessity of keeping at least the main arteries of travel free from snow. The reports seemed to indicate that municipal authorities are paying more attention to their methods of attack and consequently have formed some sort of an organization. Some now recognize the efficacy of beginning work while the snow is falling. The reports agree that wherever possible effective machinery should be used to reduce dependence on labor to a minimum, including the use of equipment available for temporary conversion to snow fighting.

—Electric Railway Journal, Feb. 26, 1921.

SLOW SPEED MOTORS AND THEIR APPLICATION TO RECIPROCATING AIR COMPRESSORS

By R. O. Joslyn, '19, Sales Engineer, General Electric Co.

Progressive and alert manufacturing companies are constantly on the lookout for more efficient ways and means of attaining certain results. If the product is satisfactory in quality and quantity, the efforts for improvement are expended in endeavoring to find cheaper, quicker, and better ways of manufacturing this product. Thus when the synchronous motor was introduced into the industrial and electrical world it was recognized as a very efficient and flexible machine to apply to equipment that had heretofore been driven by less efficient slow speed steam or gas engines.

The reciprocating air compressor and its driving element was found to be a decidedly more efficient unit when the driving element consisted of a direct connected synchronous motor than when a steam engine was employed. It also made a very compact unit and was especially desirable wherever space was an important item. Before proceeding any further it should be made clear that air compressors are not always driven by direct connected synchronous motors when electricity is available; many installations are made up of belted equipment using synchronous, induction, and direct current motors. The belted motor usually run at a speed approximately five times the compressor speed which varies from 75 revolutions to 300 revolutions per minute. However if a complete analysis were made of the various types of motors used with air compressors it would require more than the allotted amount of space available for this article and hence the following treats with direct connected synchronous motors only.

The standard electrical material furnished for an air compressor installation consists of the synchronous motor, belted exciter, rails or foundation caps, and a control panel. The motor is furnished to the compressor builder without beatings, base or shaft. The rotor of the motor is pressed, by means of hydraulic pressure, directly on the shaft of the compressor; the stator is mounted in line with the rotor and concentric with the shaft and rotor. The stator rests on the cast iron rails which are set in the concrete foundation. The rails are approximately 2 inches thick, 15 inches long, and 8 inches wide, and serves the purpose of

allowing the stator to be moved along the rails in case it is necessary to work on the rotor. If the motor is to be installed where facilities are not available for pressing the rotor on the shaft, it is necessary to furnish a split rotor which can be belted on the shaft. It is sometimes more convenient to ship the stator in two pieces also but this is usually supplied as one piece.

The belted exciter may be mounted on the floor a few feet from the compressor. A small pulley is mounted on the compressor shaft of a diameter approximately five times the diameter of the exciter pulley so that the exciter will run at a speed five times as fast as that of the compressor. It is evident that a direct connected exciter to run at 150 or 200 R. P. M. would be considerably larger and more expensive than an exciter running at 1000 R. P. M. Therefore for this particular service a belted exciter is always preferable to a direct connected exciter. The exciter is a small direct current generator of the compound wound type. It is adusted for flat compounding, that is 125 volts at no load and at full load. A typical installation is shown in Fig 1.

The synchronous motor panel should be installed in a convenient place and arranged so that the operator may have an unobstructed view of the motor when operating the switches at the panel. The slate panel is mounted on pipe supports and the essential equipment is as follows:

1—A. C. Line ammeter.
1—D. C. Field ammeter.
1—Exciter field rheostat and hand wheel.
1—Compensator mounted in back of panel.
1—Double pole field switch with discharge resistance clips
1—Triple pole double throw main and compensator line oil circuit breaker.
1—Triple pole single throw starting oil circuit breaker.
1—Lever mechanism with overload trip for the main oil circuit breaker, mechanically interlocked with
1—Non automatic lever mechanism simultaneously operating the starting and compensator line oil circuit breakers.
1—Time limit lock to prevent starting the motor except from the starting taps of the compensator.
1—Undervoltage device for main breaker.

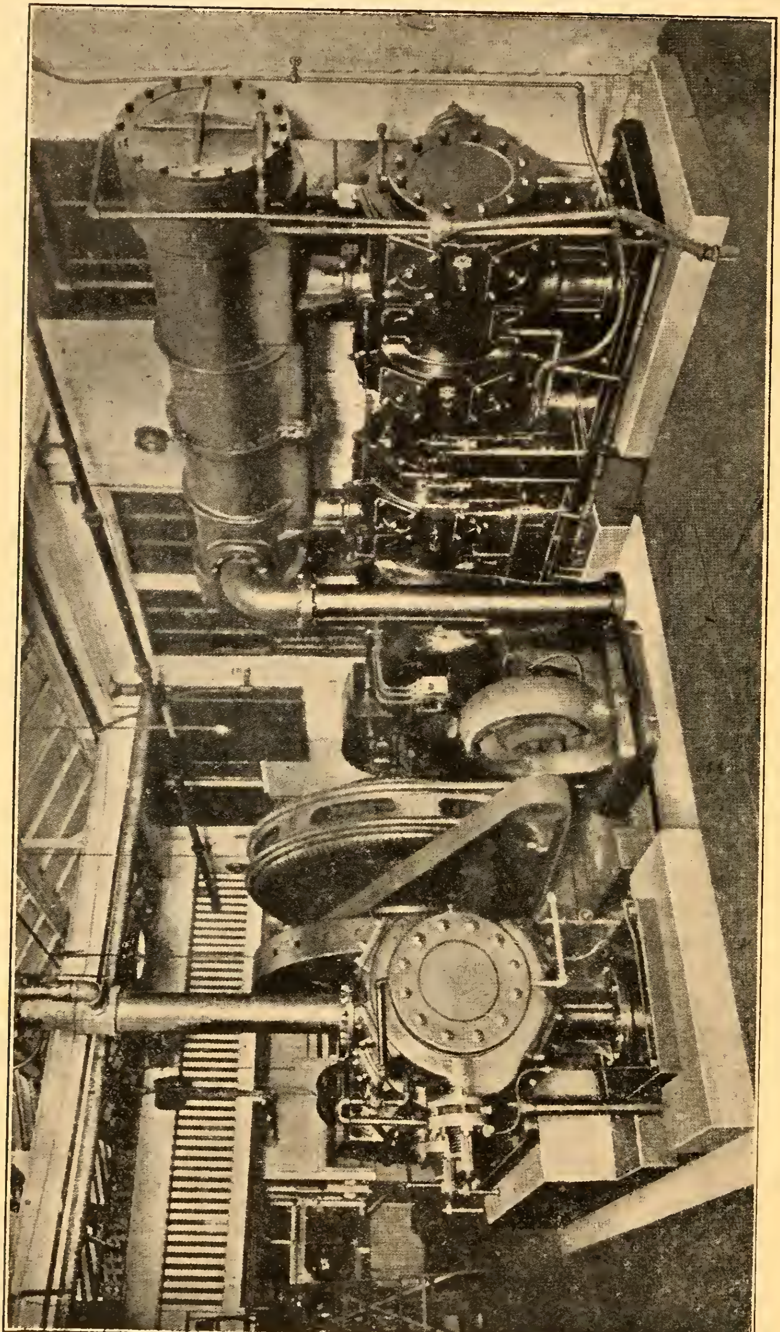


Fig. 1.

2—Current transformers.

1—Potential transformer for undervoltage device.

2—Inverse time limit overload relays.

1—Pilot lamp for exciter circuit.

The starting lever is located on the left side facing the panel. The undervoltage device is placed between the two operating levers. The motor field switch with the barriers is located on the right hand side and in the center of the board. The two overload relays are placed on the upper left side; the ammeters and exciter field rheostat handwheel occupy the extreme upper part of the board. The pilot lamp is secured to the upper edge of the panel where it is in plain view to the operator. In back of the panel and mounted on the pipe framework the compensator is placed. This is merely an auto-transformer to enable the motor to be started on 50, 60 or 70% of line voltage. If the compensator has a capacity of over approximately 300 Kva, it is mounted on the floor instead of the pipe supports due to its excessive weight. In addition to the equipment mentioned above it is sometimes necessary to furnish a rheostat in the motor field. This is only necessary however when two or more machines are excited from a common source such as a direct current bus or a motor generator set; but if an individual exciter is furnished with a synchronous motor an exciter field rheostat only is required.

The starting switch and running switches are mechanically interlocked so that it is impossible to close the running switch first. There is also a time limit interlock arrangement which necessitates throwing in the running switch immediately after releasing the starting switch. In case the operator fails to complete this operation within the specified time the running switch cannot be closed and it is necessary to repeat the starting operation. A wiring diagram of a panel is shown in Figure 2. Briefly the method of starting the unit is as follows:

The starting oil switch lever is closed.

This operation closes the two oil switches A and B which are controlled by a tandem mechanism and close simultaneously. The switch A connects the compensator to the line and the switch B connects the starting tap of the compensator to the motor. After the motor has reached the maximum speed it can attain at this voltage, the field switch is closed, and the rotor is pulled into step. The starting lever is then tripped out and the running

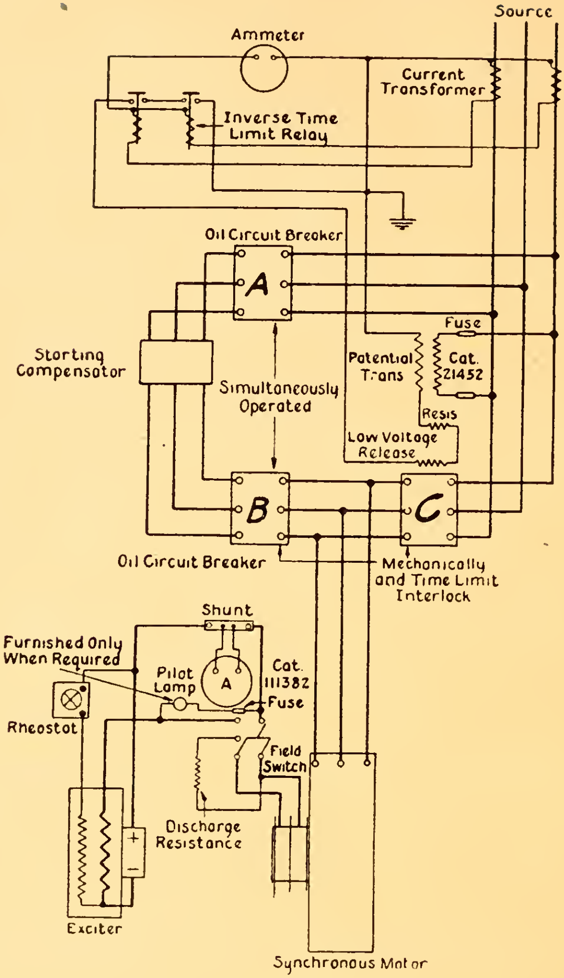


Fig. 2

switch C closed immediately. The motor is now connected directly to the line and the compensator completely disconnected. The rheostat can be adjusted to give the desired power factor which is usually unity when the motor is carrying full load. The pilot lamp on the panel is connected directly across the armature of the exciter in order to indicate when the exciter is delivering full voltage to the motor field.

The starting torque required by an air compressor with the by have the correct starting torque, pull in, and break down torque.

The starting torque required by an air compresser with the by starting torque varies with each compressor and it is well for the compressor builder to notify the electrical manufacturer of the starting torqque actually required so that the synchronous motor may be designed to take care of the particular job for which it is intended. The synchronous motor is started similarly to a squirrel cage induction motor, and as in the case of the induction motor the starting torque depends primarily upon the design of the amortisseur winding. A high resistance winding means a high starting torque and a low resistance winding means a low starting torque. To present this point more clearly the rotor may be considered to have two windings or two paths, for carrying the current, connected in parallel. The amortisseur winding is one winding and has a fixed resistance. The field winding is the other path and its resistance may be infinite which it is when the field switch is open or it may have a definite value as when a discharge resistance is connected across the field terminals. However from the law of parallel circuits it may readily be seen that the complete circuit has maximum resistance when the field circuit is open and as soon as the field circuit is closed through a resistance the resistance of the complete circuit is lessened and there is a lower starting torque. The starting torque of a synchronous motor also varies as the square of the voltage of the supply circuit. Since the starting compensators are provided with three taps it is evident that if the motor fails to start on the lowest tap the connections may be readily transferred to the next higher tap. It is advisable to keep the motor connected to the lowest tap which will give the required starting torque as the current in rush is less on the lower tap.

The synchronizing torque or pull in torque also depends upon the resistance of the amortisseur winding. A high resistance rotor furnishes low pull in torque and vice versa. Thus it will be noted that good starting torque is obtained by sacrificing the pull in torque. The most advantageous arrangement is to design the amortisseur winding so that maximum torque will occur at one half synchronous speed as this will give about the same amount of static and synchronizing torque. With the proper value of resistance across the collector rings the torque near full speed is increased. A change from this resistance in either direction will decrease the torque. An accurate and convenient way of deter-

mining the proper resistance is to bring the motor to constant speed at full voltage with the load it has to pull into synchronism, then by means of a water rheostat or some other variable resistance connected across the collector rings, to determine the resistance which will increase the speed to the highest value. The discharge resistance should be designed to contain this ohmic value. The discharge resistance also serves the purposes of dissipating the excessive field energy when the field switch is opened. There is another factor that influences the starting torque and that is the field windings. To insure maximum starting torque the field switch should be open, which means that the field coils are open circuited and infinite resistance is in this particular circuit. The above method is resorted to in case conditions arise in service where the pull in torque requirements prove to be greater than were anticipated at the time the machine was designed. It is always advisable to synchronize the motor when running from the compensator if possible as the motor may then be thrown directly on the line with very little disturbance.

The third torque value to be considered in the synchronous motor is the pull out or break down torque which varies from 150 per cent to 300 per cent of normal torque in standard machines. The pull out capacity varies directly as the terminal voltage and also directly as the field excitation. It may be calculated directly from the saturation and synchronous impedance curves of the machine or by theoretical formula, the former method is more accurate as it gives the actual values while the latter method furnishes theoretical results. Let Figure 3 represent the saturation curve and the synchronous impedance curve of a synchronous motor.

F is the value of field current necessary to produce normal terminal voltage E_n. F_1 represents the field excitation required to obtain normal armature current from the synchronous impedance curve and F_2 is the value of field current at full load. The power furnished to a synchronous machine at break down is

$P = \dfrac{\text{voltage x current}}{1000} \sqrt{3} \text{ Cos } \theta$ K. W. Therefore at a terminal voltage E_n and a field excitation F_1 corresponding to normal armature current, the pull out capacity would be equal to

$P = \dfrac{\sqrt{3}\, E_n\, I_n}{1000}$ Cos θ K. W., which is the normal rating of the motor. Then at an excitation F_2 corresponding to a current of

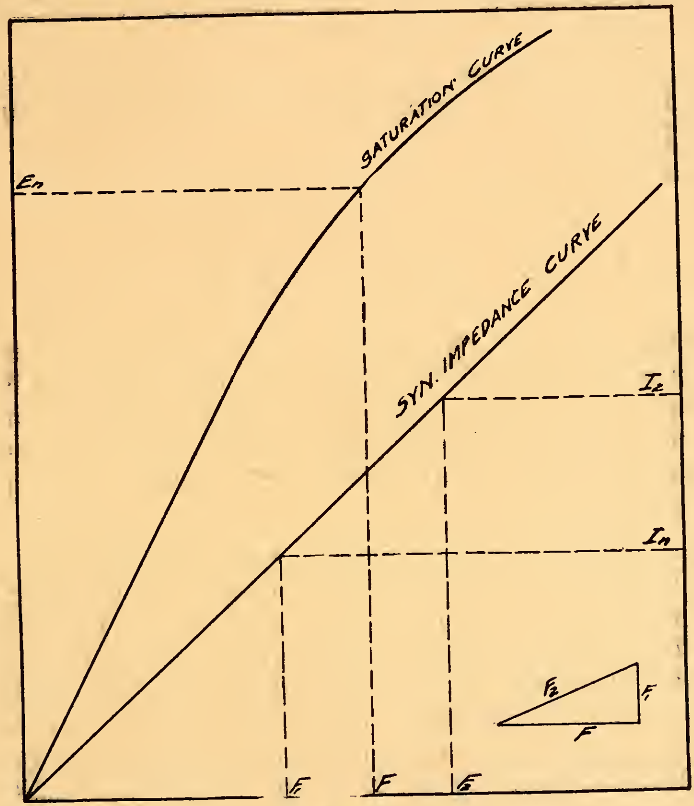


Fig. 3.

I_2, on the synchronous impedance curve and the same terminal voltage as before the power will be $P = \dfrac{\sqrt{3}\, E_n\, I_2}{1000}$ Cos. θ K. W. That is the break down capacity at a field excitation F_2 is equivalent to $\dfrac{I_2}{I_n} = \dfrac{F_2}{F}$ times the normal Kva rating of the machine. The ratio of the field excitation corresponding to nor-

mal voltage on the saturation curve, to the field excitation corresponding to normal armature current on the synchronous impedance curve is known as the short circuit ratio. Therefore the short circuit ratio $K = \frac{F}{F_1}$. The magnetomotive force diagram of a synchronous motor at unity power factor illustrating the position of the field current values is shown by the small sketch in Figure 6.

Therefore $F_2^2 = F^2 + F_1^2$.

$$\frac{F_2}{F_1} = \sqrt{\frac{F^2}{F_1^2} + 1} = \frac{F_2}{F_1} \sqrt{1 + K^2}$$

When the short circuit ratio K is known the pull out capacity is approximately equal to $\sqrt{(1 + K^2)}$ times the normal Kva. rating of the machine. The above formula is true of a unity power factor machine only. For instance if a 300 Kva. unity power factor machine has a short circuit ratio of 1.4, the pull out capacity would be

$$300 \sqrt{(1 + 1.4^2)} = 300 \times 1.72 = 516. \text{ KW.}$$

When two or more synchronous machines are operating on the same system they must run at the same average electrical speed. The electrical speed is determined by the frequency of the circuit. There is an elastic or synchronizing force which tends to keep the machines rotating at the same speed; in case a machine tries to speed up it is held back and if it has a tendency to lag, the synchronizing force will pull it up into the position of uniform rotation. By position of uniform rotation is meant the position which the rotor would occupy with respect to the rotating field, if running at no load with a constant driving force. The air compressor presents a decided variable load throughout each cycle. The variations are periodic and of sufficient magnitude to cause considerable trouble if precautions are not taken. Any change in the load itself compels the motor to readjust itself to the changed conditions, its tendency being to slow down with increase in load and to speed up when the load is reduced. Each time the rotor is thus displaced there is a heavy inrush of line current which returns to normal as soon as the rotor is in the position of uniform

rotation. The increase in current means a large line drop and consequently if lights are supplied from the same circuit there is a variation in voltage. With every revolution of the compressor the lights will flicker or perhaps burn out. To limit these deviations of the rotor it is often ecessary to add a fly wheel to the

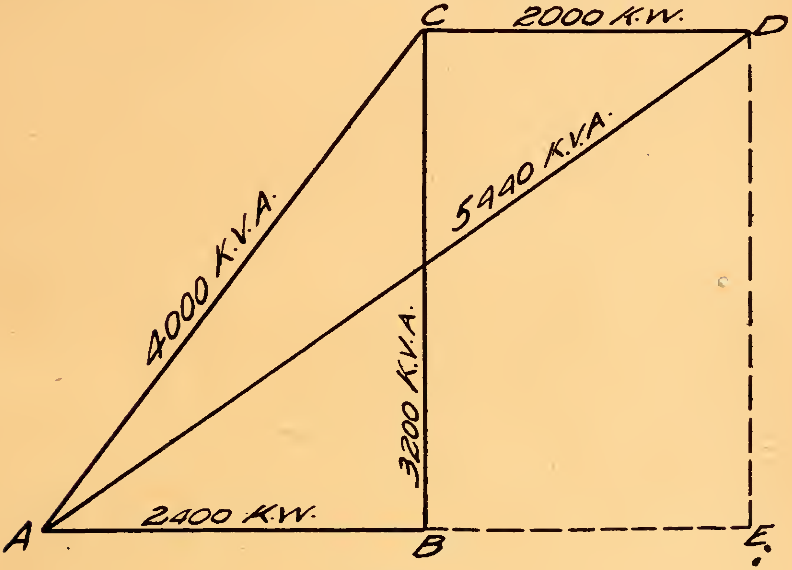


Fig. 4.

unit which will give the rotor sufficient inertia to keep it running comparatively uniformly. The allowable displacement is 3½ electrical degrees plus or minus from the neutral position of rotation. From the torque effort diagram of the air compressor it is possible to calculate the fly wheel effect necessary for satisfactory operation. The rotor of the motor of course has a certain amount, but in case the value is not sufficient to limit the angular duration to 3½ electrical degrees, a fly wheel must be added. The torque effort diagram is calculated from the indicator cards, weight of the reciprocating parts, radius of crank circle and other data obtained directly from the compressor.

Synchronous motors are especially desirable for air compressor service when the system has poor power factor characteristics. Induction motors and transformers involve a lagging power especially when underloaded. A poor power factor means larger generators than necessary, higher cost, lower efficiency, and poor

regulation. Several power companies, realizing the disadvantages of a low power factor, penalize their customers if the power factor of the individual plants are below a certain value. It is often the case that a compressor is only required to deliver full load part of the time and thus it is possible to operate the motor on unity power factor when delivering full load and at a leading power factor when operating at part load. It is also possible to design a synchronous motor to carry full mechanical load and have available a sufficient amount of reactive Kva. available for power factor correction purposes. It is possible to operate the motor at unity power factor by adjusting the field rheostat until the line or armature current is a minimum for a given mechanical load. At this point the current is neither leading nor lagging the voltage and the total power input is being used to drive the load and to overcome the losses in the machine. If the excitation is increased beyond this point the current leads the voltage and the machine is said to be operating at leading power factor, and if the excitation is decreased below this point the current lags behind the voltage and a lagging power factor results. A synchronous motor is capable of operating at any power factor from zero to unity if the fields are designed to carry the current without overheating. A unity power factor machine cannot operate at .8 p.f. and still maintain its full rated load without overheating. However an .8 p.f. motor can operate at unity without overheating due to the fact that the minimum amount of armature current and a smaller field current is required at unity power factor and thus less heat is generated. It is evident therefore that a unity power machine operates more efficiently than at any other power factor; and also the first cost is lower on account of the fact that a smaller machine is required at unity than at any other power factor. A unity power factor machine, when working under full load, does not deliver any wattless Kva. to the line but it does improve the power factor. However if the load is decreased and full load excitation applied, a certain amount of reactive Kva. is available. From the above discussion it will be noted that the power factor of a system will be aided by a synchronous motor. The amount of this correction will depend upon whether the machine is (1) a unity power factor motor, (2) a power factor motor delivering part mechanical load and part corrective load and (3) a synchronous condenser in which all the input to watt-

less leading current is used for corrective purposes. It is evident under case 3 that a synchronous motor could not operate at zero power factor and also drive a compressor. However, to make the explanation of power factor correction complete the effect of a synchronous condenser on the line has been brought

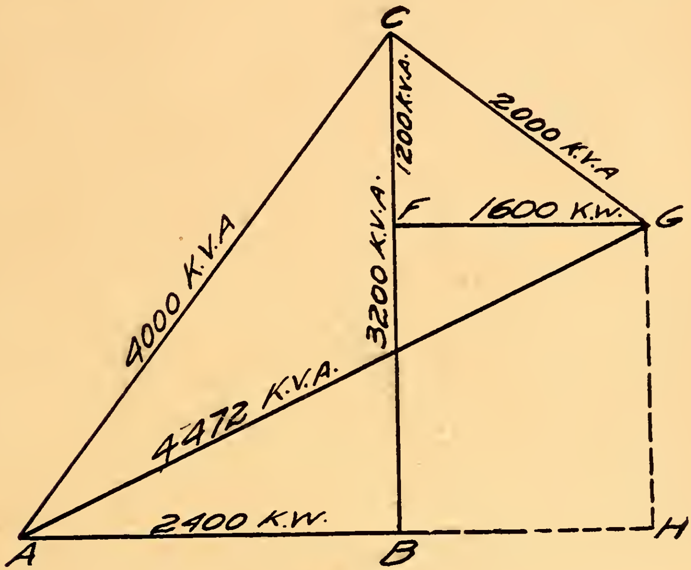


Fig. 5.

up in connection with the other two illustrations. The following examples will illustrate the three uses: An industrial plant has a load of 2400 K. W. at .6 p. f. or 4000 Kva. If a 2000 Kva. synchronous motor is added to the system the effects at (1) unity power factor, (2) .8 p. f., and (3) zero power factor will be as follows:

(1) *As a unity power factor motor,* fig. 4.

Let the line A. B. represent the energy load of 2400 K. W. The

Kva. $= \dfrac{2400}{.6} =$ 4000 Kva. and is represented by A. C. The

wattles energy is equal to B. C. $= \sqrt{(AC^2 - AB^2)} = \sqrt{(4000^2 - 2400^2)} =$ 3200 Kva. A 2000 Kva. 1.0 p. f. synchronous motor is added and represented by the line C. D. The total energy load is

now 4400 K. W. and the reactive Kva. remains 3200 Kva. The total power is A. D. $= \sqrt{(AE^2 + DE^2)} = \sqrt{(4400^2 + 3200^2)} =$ 5440 Kva. The new power factor of the system is now $\frac{4400}{5440} = .81$. Therefore using a 2000 Kva. synchronous motor the power factor has been increased from .60 to .81. The actual mechanical

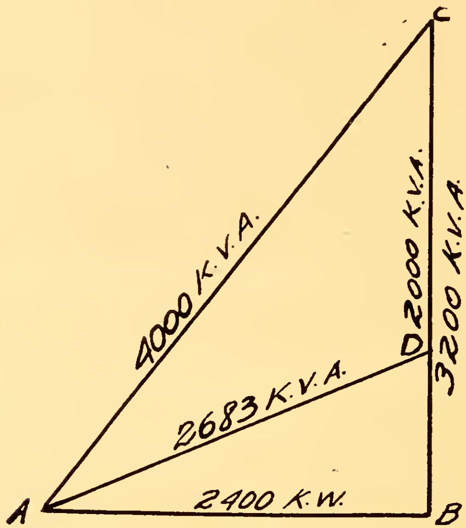


Fig. 6.

load on the system has been increased 83 1-3% while the generator capacity has been increased only 36%.

(2) *As an .8 power factor motor fig.* 5.

Referring to Fig. 5 the lines A. B. C., B. C. and A. C. represent the energy load, wattless Kva. and total Kva. respectively. A 2000 Kva. .8 p. f. synchronous motor is now added to the system. This will mean that .8 x 2000 K. W. or 1600 K. W. energy load and 1200 wattless Kva. has been added. The wattless Kva. of the synchronous motor will neutralize an equal amount of wattless Kva. of the system due to the fact that the synchronous motor furnished wattless leading Kva. as against wattless lagging Kva. of the load. The line C. F. represents the leading wattless Kva. and F. C. the energy of the motor. The total energy load is 4000 K. W. and wattless Kva. 2000 A. G. is the total Kva. of

the system and is equal to $\sqrt{(AH^2 + GH^2)} = \sqrt{(4000^2 + 2000^2)} = 4472$ Kva. This is the rating of the generator necessary to carry the total load. The new power factor is now $\frac{4000}{4472} = .895$ instead of .60. In this case the energy load has been increased 66⅔% and the generator capacity approximately 12%.

(3) *As a synchronous condenser fig.* 6.

A synchronous condenser operates at zero p. f. and is for corrective purposes only. There is no mechanical load available in this case and the total Kva. is wattless leading. In fig. 6 the same notation is used; the mechanical load, wattless Kva. and total Kva. being represented by AB, BC and AC respectively. The 2000 Kva. synchronous condensor is now applied. The leading wattless Kva. of the synchronous condensor is noted as CD and is opposite in direction to BC. The energy load remains unchanged but the wattless Kva. is now BD = 3200 — 2000 = 1200 Kva. The total Kva. is A. D. $= \sqrt{(AB^2 + BD^2)} = \sqrt{(2400^2 + 1200^2)} = 2683$ Kva. The new power factor is now $\frac{2000}{2683} = .895$. Al though no mechanical load has been added the total Kva. has been decreased from 4000 to 2683 and therefore a generator of only two thirds capacity is required and relative decrease in the transformers, cables and oil switches.

From the above examples it may be noticed that a synchronous motor air compressor unit will increase the power factor of an alternating current system materially.

The above discussion has not gone into the theory of air compressors or synchronous but has dealt with the practicable side of the subject. There are several text books which explain the theory of these machines in detail, to which the reader may refer if sufficiently interested. In conclusion the main advantages of synchronous motor air compressor units are efficiency, minimum space, simplicity of operation, and flexibility of power factor correction.

CHEMICAL FIRE EXTINGUISHERS

Norman F. Kimball, M. E., F. P. E., Chief Engineer, the O. J. Childs Company, Inc., Utica, N. Y.

Foreword.

Practically all fires are small at the beginning and many fires are discovered in their incipiency. For the lack of a chemical fire extinguisher or other suitable means of extinguishing fire millions of dollars worth of property have been lost and many human lives sacrificed. Chemical fire extinguishers are designed to take care of incipient fires and they have been in successful use for many years and their effectiveness is universally recognized. The soda-and-acid fire extinguishers are thoroughly standardized and at the present time there are over 1,000,000 of them in use in this country, guarding factories, warehouses, mercantile establishments, hotels, etc.

General Design.

Chemical fire extinguishers of the soda-and-acid type have a total capacity of three gallons and a solution capacity of two-and-one-half gallons. Generally speaking, a chemical fire extinguisher consists of a closed cylindrical container partially filled with a solution of water and bicarbonate of soda and a small quantity of commercial sulphuric acid in a glass bottle which is supported at the upper end of the tank. The acid bottle is closed by means of a loose stopple which is generally made of lead. The opening at the top of the extinguisher through which the chemicals are placed is fitted with a threaded brass collar, and this opening is closed by a brass cap which threads on to the collar. A length of rubber hose fitted with a nozzle, is attached to a discharge elbow, and is used to direct the stream.

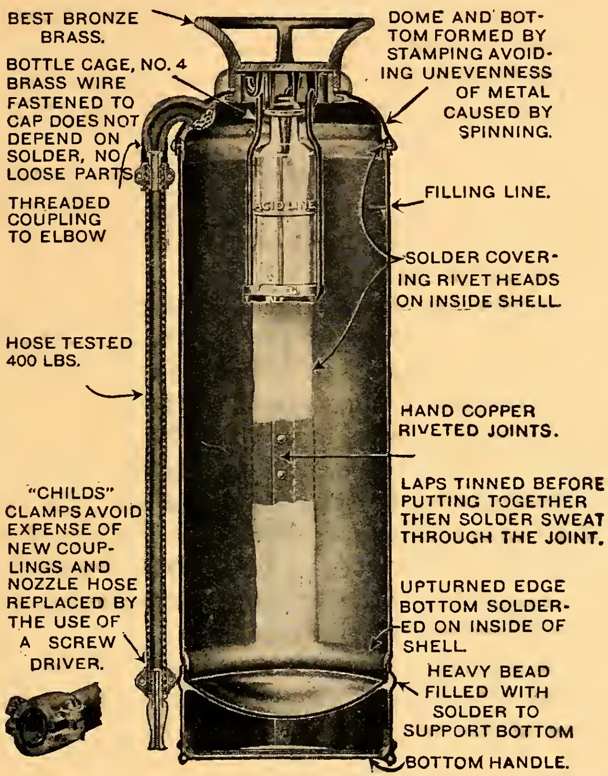
Construction.

The illustration shows a three-gallon soda-and-acid extinguisher manufactured by the O. J. Childs Company, Inc., of Utica, N. Y.

The tank proper of a "Childs" chemical fire extinguisher is made of a copper cylinder with convex heads. The cylinder is of cold rolled Lake Superior copper, properly tempered, and of No. 18 Brown and Sharp gauge, this thickness of copper being sufficient to make the tank strong enough to withstand a hydrostatic pressure of 350 pounds per square inch without distortion. The vertical or longitudinal seam is riveted with a row of copper

rivets, the seam is sweated with solder, which is made to flow through the outer edge, and in addition the joint is backed on the inside with solder which makes a smooth covering for the

CROSS SECTION SHOWING CONSTRUCTION
"CHILDS" EXTINGUISHER.



rivet heads on the inside of the shell. This form of joint is very strong, in fact stronger than the copper sheet itself, for in hydrostatic pressure tests to break down the tank invariably fails, or rupture occurs, in the sheet and not at the joint.

The top and bottom heads are formed by stamping and are of a heavier gauge of copper than the shell. The top head or dome is riveted to the shell—this being a special feature of "Childs" extinguishers—and the joint is sweated and finished in a similar manner to the vertical seam described in the preceding paragraph. The bottom head is set up against a small bead and adjacent to a large bead which is rolled in the shell. The space

between the larger bead and the bottom head is banked with solder and the joint is sweated.

The interior of the extinguisher shell and all surfaces of the various brass fittings which are exposed to the solution contents are coated with a lead-tin alloy as a protection against corrosion.

The lower edge of the shell, which rests on the ground when the extinguisher is standing normally upright, is strengthened by means of a stiffening ring. This stiffening ring is a steel wire inserted in a bead and around which the lower edge of the shell is spun.

The correct amount of solution which is to be placed in the tank is shown by means of a filling indicator or marker. This indicator is a copper angle piece which is soldered to the inside of the shell at the correct level.

The extinguisher cap which threads down on to the collar is designed so that the threads are protected against exposure to the contents of the extinguisher. This cap is provided with a ring handle to facilitate its removal and replacement on the collar.

The acid bottle is supported in a removable cage in some types of extinguishers but in the case of the "Childs" extinguisher the acid bottle cage is fastened to the under side of the tank cap. The stopple which closes the opening in the acid bottle is of special composition metal, mostly lead, with a small percentage of antimony. The stopple is designed in proportion to regulate the flow of acid when the extinguisher is inverted.

The hose on chemical fire extinguishers is generally of the 3/8″ size and about 17″ in length. The nozzle is cast of composition metal, similar to that of which the stopple is made.

Operation.

To operate a soda-and-acid extinguisher it should be carried to the fire by means of the top handle and then put into operation by merely inverting it. When the extinguisher is inverted the loose stopple falls partly out of the bottle, and the acid is gradually fed into the soda solution. The chemical reaction between the acid and soda solution liberates large quantities of carbon dioxide, commonly known as carbonic acid gas. This immediately generates comparatively high pressure in the extinguisher which forces the solution out of the nozzle at a sufficiently high velocity to provide a good fire stream. The stream can be directed by the hose and nozzle.

It may be seen from the preceding paragraphs, that soda-and acid fire exitnguishers are self contained units. Normally, they stand without being under pressure, but just as soon as they are operated they generate their own pressure and discharge a fire stream about 40 feet in length.

The pressures generated in chemical fire extinguishers depend upon various features of design and condition. These various features are the rate of acid feed, the amounts of soda and acid used, the liquid capacity of the tank, total capacity of the tank, the diameter of the nozzle orifice and the temperature of the solution at the time of operation. The correct rate of applying the acid is controlled by the design of the inner diameter of the acid bottle neck, the diameter and length of the stopple, and the distance the stopple falls away from the bottle when the extinguisher is operated. In addition to providing correct operating pressures it is necessary that the solution discharge be alkaline in character and have no trace of acid at any time during the stream discharge.

Under ordinary solution temperatures, say about 70 degrees Fahr., the pressure of about 40 pounds is obtained in five seconds after the extinguisher is operated, the pressures gradually increase up to about 100 pounds in approximately 25 seconds and from then on they gradually decrease until the solution is entirely discharged. The duration of discharge is about 60 seconds.

Strength.

Approximately all of the soda-and-acid extinguishers now manufactured are built under the rigid specifications of the Underwriters' Laboratories and each machine bears their label. It is one of the requirements of the Underwriters' Laboratories that these devices be of such strength that when tested to a hydrostatic pressure of 350 pounds per square inch, they show no distortion or permanent set. These extinguishers when tested to break-down, do not fail or burst at pressures below an average of 500 pounds per square inch. In a test made upon a "Childs" extinguisher, failure of the tank did not occur until a pressure of 700 pounds per square inch had been impressed upon the device. Since the average maximum working pressure is about 100 pounds it can be seen that these devices provide an ample factor of safety and are thus safe-guarded against failure under average service conditions.

Fire Extinguishing Efficiency.

The theoretical chemical reaction that occurs in a chemical fire extinguisher of the soda-and-acid type is as follows:

$$2\ NaH\ CO_3 + H_2SO_4 = 2CO_2 + Na_2SO_4 + 2H_2O$$

A chemical fire extinguisher, when properly charged, contains water, bicarbonate of soda, and commercial sulphuric acid. The bicarbonate of soda is dissolved in the water and as soon as the acid is allowed to mix with this soda solution, a violent effervescence or bubbling takes place. This chemical reaction forms large volumes of carbon dioxide gas. This gas will not support combustion, it having a great smothering or choking effect on fire, and it is the presence of this gas which helps to make the chemical fire extinguisher so effective.

The products discharged from a chemical fire extinguisher, as shown by the above equation, after operation may be listed as follows:

1. Water which was originally put in the device.
2. Water formed in the chemical reaction.
3. Water which was in the acid.
4. Sodium sulphate, a heavy insoluble salt.
5. Carbon dioxide gas.
6. Bicarbonate of soda, which was not used up in the chemical reaction.

The fire extinguishing value of the fire stream discharged from a chemical fire extinguisher is, therefore, due to the following properties:

1. The presence of large volumes of carbon dioxide gas, which acts as a blanket, displaces the air, thus robbing the fire of oxygen without which combustion cannot take place, and smothers the flames. Carbon dioxide gas is heavier than air and has a tendency to settle down into confined and inaccessible places, where water cannot reach, driving out the oxygen and thereby smothering the fire.

2. The cooling effect of the water or the absorption of the heat in vaporizing the water which was originally put into the device, the water which was in the acid, and the water formed in the chemical reaction. When water strikes a fire, the heat turns it into steam and since it requires quite an immense amount of heat to change water into steam, the temperature of the burning materials are lowered to the point where they are so cool they

cannot burn. The clouds of steam also crowd away the air and smothers the fire.

3. The sodium sulphate is carried along in the stream and covers the burning substance with a crust-like salt forming a fire-retardant coating on the burning materials retarding combustion. A very similar effect to this is that of pouring sand on a fire.

4. In charging an extinguisher more bicarbonate of soda is used that is actually needed so as to insure that all of the acid will be neutralized. This excess of soda which is not used up in the chemical reaction is decomposed or broken up, when it strikes the fire, into carbon dioxide and carbonate of soda, the former smothering the fire, and the latter acting as an inert coating and retarding combustion in the same manner as the sodium sulphate.

Summarizing, fires are extinguished in the following ways: first, by cutting off the supply of air from the burning materials; second, by lowering the temperature of the materials so that further combustion is impossible. In chemical fire appliances, the combustion of the soda solution and carbon dioxide gas provides the means for extinguishing the fire. The solution acts as a carrying agent for the excess soda and when this stream strikes the base of the flames, it cools off the burning materials and at the same time the gas crowds the air away and further combustion is impossible.

On wood fires, or fires in free-burning material of any kind, and 99% of all fires are of this kind, chemical fire appliances are in every respect the most efficient that can be put in use. The reason for this is that in fires of this kind or any fires with a broken surface, it is necessary to have a steady stream with pressure behind it to send into a fire and cool it off, in addition to depositing enough carbon dioxide to prevent combustion.

Recharging and Maintenance.

Chemical fire extinguishers should be charged promptly after use on a fire or if not so used, recharged at least once a year. In so far as it is practicable each extinguisher should be emptied by discharging as though on a fire. It is highly desirable at these yearly inspections, to discharge the extinguisher as if at a fire before the persons who are likely to use the extinguisher. In this way valuable knowledge is gained of the operation of the devices.

To recharge, the extinguisher should be placed upright on the floor, the cap unscrewed, and the acid jar removed. The tank or

cylinder should be emptied and thoroughly cleaned, removing deposits of soda left in the tank from the old charge. The extinguisher should be partly filled with water and then inverted enough to drain through the hose. If any obstructions are apparent the hose and nozzle should be cleaned. The soda should be completely dissolved in 5 or 6 quarts of clear water, luke warm water being preferable. When the soda is all dissolved and the solution clear, it is poured into the tank and clean water added to fill to, but not above, the filling mark on the inside of the tank. The stopple is placed on the glass bottle, which is filled with acid to the filling mark on the glass, and the bottle replaced in the cage. The threads in the collar and cap should be cleaned and oiled with plain vaseline and the cap then threaded tightly on the collar. Record tags are attached to most chemical extinguishers and the date of recharging, together with the signature of the person who performed it, should be written on this tag.

Suitability.

Chemical fire extinguishers are especially adapted for use as first aid fire appliances in extinguishing incipient fires. They are effective upon all fires in structural material, ordinary furniture, machinery, and containers for merchandise. They are especially suited for fires above floor levels, and upon fires in all substances that mix with water.

The Underwriters' Laboratories classify these devices as follows:

"Extinguishers of loose stopple and break bottle types using soda and acid are effective on incipient fires in free burning material (such as wood etc.) and where water of solutions containing large percentages of water are effective. They are of limited service on fires in liquids of a flamable nature. Their use on electric arcs, electric machinery, on wiring carrying high voltages may be dangerous on account of the conductivity of the liquid."

Chemical fire extinguishers can be readily operated while being carried about and can also be handled by women. The force, length and duration of the stream are not dependent upon the operator. These devices are recommended for use in factories, public buildings, stores, theatres, hotels, residences, hospitals schools, etc., etc.

Distribution and Arrangement.

Since the needs of each individual property are peculiar, a general rule cannot be made as to the number of chemical fire extinguishers necessary. The local underwriters having jurisdiction in the territory where the property is located should be consulted before chemical fire extinguishers are installed. In some localities one extinguisher is required for every 2,000 or 2,500 square feet of floor area, figuring each room, gallery, etc., separately; and in other localities two extinguishers are required for the same floor area.

It is very good practice to locate chemical fire extinguishers so that the travel from any point to the nearest extinguisher will not be greater than 35 feet in any direction. These devices ought not be grouped together except in such properties as churches, schools and strictly office buildings where corridor distribution and grouping may be necessary to some extent. In many industries temporary hazards occur from time to time and to properly protect these it is found good practice to maintain a few portable stands or racks provided with extinguishers which can be located near the special hazards.

In order that the extinguishers will be immediately available in the event of fire, they should be distributed and located where they will be readily accessible. The practice of painting some sort of a sign, of sharply contrasting colors, on the walls, well above the device has been found very satisfactory in buildings where the extinguishers are likely to be obscured by piles of stock, lumber, etc. These signs become familiar to the occupants of the building, bring the apparatus into distinct prominence, and thus tend to save valuable time in a case of fire.

Susceptibility to Freezing.

When located where temperatures lower than freezing point, (32 degrees Fahr.), may be encountered, chemical fire extinguishers should be protected against freezing. The soda solution of the strength used in these extinguishers will freeze at about 29 degrees Fahr., and the freezing point of sulphuric acid varies with its specific gravity from about 29 degrees to 32 degrees above zero Fahr.

Attempts have been made to depress the freezing point of the contents of chemical fire extinguishers by adding certain chem-

icals such as ordinary salt, calcium chloride, denatured alcohol, glycerine, and other less common chemicals. The use of these ingredients are not to be recommended for the following reasons:

1. Most ingredients when added have the effect of throwing a part of the bicarbonate of soda out of solution and accordingly tend to reduce the pressure when the chemical is brought into service, and to also clog up the extinguisher when used.

2. Many ingredients when added have a tendency to corrode the interior of the extinguisher.

3. Many ingredients when added may set up a reaction when the extinguisher is operated which would have possibly undesirable results.

4. The addition of any ingredients for depressing the freezing point of the bicarbonate of soda solution has no effect on the acid which of itself in many cases may freeze at or near the freezing point of water.

5. Although ingredients may prevent freezing of solution, the extinguisher at low temperatures will not be properly operative on account of sluggish chemical reaction caused by low temperature.

It is good practice to place each extinguisher in a tight wooden cabinet containing an electric light bulb which should be kept lighted continually during the cold weather. Such a cabinet should be conspicuously marked to show that it contains a Fire Extinguisher.

"Chemical Fire Extinguishers vs. Fire Pails."

The advantages chemical fire extinguishers have over fire pails are many and great. The more important may be listed as follows: (1) Reliability of operation, (2) Efficiency, (3) Maintenance, (4) Economy, (5) Appearance, (6) Sense of security.

1. Reliability of operation.

The reason why fire pails fail on the average fire in buildings is because of their limited range and difficulty of applying them. It is very difficult or almost impossible to reach with water from a pail a fire burning within flues behind sheathing, on overhead construction, or on ceilings. Where a room is on fire and the door is opened, a volume of hot smoke rolls out, completely blocking the entrance, and making it next to impossible to get the water from a fire pail near enough to the points where combustion is taking place to have it do any good.

In contrast, effective work can be done with a chemical fire extinguisher at a distance of 30 feet from a fire, if necessary, and the stream will penetrate through the flame and smoke, and reach the point where combustion is taking place. The stream from the extinguisher can also be directed so accurately that there is no waste of the fire-extinguishing solution.

2. Efficiency.

Efficiency is the real test of any extinguishing device in fighting a fire. Fire pails depend entirely upon their water contents, the greater portion of which never reaches the fifire. All the water from a fire pail is thrown on the fire at once, and there is no reserve except more pails.

The chemical fire extinguisher is self-acting, it furnishes its own motive power, acts positively and promptly, and saves much valuable time. Each gallon of water as it leaves the nozzle of the extinguisher, carries with it about twenty times its volume of carbonic acid gas. By conveying this gas along with the liquid, fires in inaccessible places can be successfully reached. The gas being heavier than air is carried between partitions etc., directly to the point where the combustion is taking place.

3. Maintenance.

One of the principal shortcomings of fire pail protection is the tendency to use them for domestic purposes. Besides this, water in fire pails evaporates and becomes foul, and the pails are found inoperative when needed at time of fire.

The chemical fire extinguisher when properly charged and not disturbed will respond with absolute certainty even after standing for a year or more. The chemicals retain their full strength and evaporation at ordinary temperatures is too small to be considered.

4. Economy.

It is true that in first cost, fire pails are cheaper than chemical fire extinguishers. However, economy in first cost is not ecônomy in the long run. The true measure of economy is where the greatest results are obtained at the least possible cost. Judged by the standpoint of service the chemical fire extinguisher, with its almost negligible maintenance cost and its wonderful fire-fighting efficiency, is the most economical form of fire apparatus obtainable.

5. It goes without saying that the appearance of fire pails is anything but handsome and it is because of this that they are judged unsuitable in many locations. Contrasted with the unsightly appearance of fire pails, we have the beautiful finish of the chemical fire extinguisher, any one of red enamel, polished copper, or nickel plate.

6. Sense of security.

When all of the water from a fire pail is thrown at a fire at once, there is no reserve except more fire pails. A nervous, excited operator at the time of fire dashes the entire contents of a fire pail on the fire and then he is through unless more pails are available. In his hurry little attention is paid to direction and as a result much of the water never gets to the fire—is wasted.

With the chemical fire extinguisher the stream can be directed by means of the hose and nozzle. The steady, powerful action of the stream reassures the nervous or excited operator and he is thus able to economize in using the contents of the extinguisher and stand his ground in the face of the hottest fire.

NEW CARS FOR CHICAGO

The Chicago Surface Lines are building fifty trailer cars in their own shops and fifty additional trailers were ordered on February 26. One hundred motor cars are being remodeled for operation in trains.

An experimental train of two cars has been in operation for several months with gratifying success.

A feature of the equipment of both the 100 new trailer cars and the 100 remodeled motor cars is the pneumatic and safety interlocking door control. This combination of pneumatic door and step control not only insures safe operation in either single car or train service, due to the impossibility of starting the cars until all doors are closed, but it also affords the advantages of labor saving, power saving, time saving, protection of motor and controllers, and reduction in car maintenance of doors, steps, and electrical equipment, with longer life and greater earning capacity for the individual car units.

——"Electric Traction," March, 1921.

VALUATION OF PUBLIC UTILITY PROPERTY

By Leslie Weiss, '18.
With Gennett, Seeley & Fleming, Inc., Harrisburg, Pa.

Valuation of public utility property during the last ten years, has opened a new field of endeavor for the engineer. The work involved in making a valuation is considered as a high grade of engineering because it requires a thorough knowledge of not only the details of design ad construction, but also of operation and financing. Engineers have been requested to give expert testimony with reference to the fair value of public utiility properties for the purpose of rate making, capitalization, and taxation, and therefore in order to substantiate this testimony it was necessary to examine the property and its records in detail.

The present era of appraisals and valuations owes its origination to those municipalities which first took over privately owned waterworks properties. Hence the waterworks engineers were the first in the profession to be drawn into this department of engineering and much of the pioneer work may be credited to them.

The establishment of various public utility commissions for the purpose of regulating the earnings of public service companies has created a demand for a fair basis upon which to determine the tariffs of these companies. It is almost universally agreed that the earnings of a corporation serving the public should be governed by the fair value of the property, its operating expenses, interest on investment, taxes, insurance, and depreciation. Because these corporations are practically non-competitive, the ordinary regulation of the rates arising through competition do not apply. Public Utility Corporations must be organized under special and specific laws, under which they are granted unusual franchises. The privileges enjoyed are distinct from those of ordinary undertakings, and therefore should be subject to special regulation and control. Also it becomes obvious that regulation governing the competition for the same business becomes necessary from the very nature of it. Experience indicates that if these corporations are allowed full and free competition, ultimately they will engage in a warfare that will result in the anni-

hilation of one or more of the competitors, the expense of this being borne by the public.

To show just what are the duties of an engineer engaged in this work an outline of the proceedure is given. Suppose that a company selling electrical energy throughout a territory decides to increase its rates. First it is necessary to prepare a tariff showing the intended changes, and to file it with the respective public utility commission. The application of higher rates usually is met with protest from the consumer. The objections are initially introduced to the operating company through the medium of the various civic organizations such as the business associations, and the chamber of commerce. If no satisfactory adjustment results from the appeal of the public, a complaint may be entered with the Public Service Commission of the State. This body as a rule determines the seriousness of the complaint at a preliminary hearing, where representatives of both factions are present. Usually the evidence produced by the company at this meeting is insufficient to justify its action, and generally the commission advises that experts be employed to make a thorough investigation of the property relative to its present fair value. Occasionally the public also engages engineers to make similar examinations of the property.

The purpose of these investigations is a definite logical one, namely, to ascertain a fair value for a specific piece of property at a given time, but this is not always an easy task, owing to the many factors which must be considered. Exact precision may be impossible owing to the fact that no two properties are exactly alike; prices of material and labor fluctuate, property conditions are changing, workmen are liable to err, and hence it becomes obvious that the object may unconsciously prejudice the investigator favorably or unfavorably. Therefore, an individual endeavor to obtain a just final figure will probably find that the result differs from that of another expert of equal integrity. But in all cases the actual engineering facts such as measurements, quantities, and unit prices, should be agreed upon by the opposing sides.

Further, there should be no confusion of thought or misapprehension as to the fact that there is only one legitimate, definite value for property determined by the historic cost, or the reproduction value for a certain definite period.

It should be definitely agreed, prior to a detailed examination of the property, which of these methods is to be employed. The method of depreciating the property also should be agreed upon at this time, namely, the straight formula or the sinking fund method. Sometimes a figure based upon each method is presented; however, as a rule, the engineers work upon the basis which is favored by the various commissions in previous decisions. Whether the historic cost or reproduction value is used to derive this particular value, the details of it must not be modified to suit the purpose for which the report is to be used. It should present a true status of conditions.

For the purpose of differentiation between the two methods just mentioned a brief definition of each term is given.

The historic cost of an item or a piece of property is its cost at the time of its installation, whereas the reproduction value varies from year to year, depending upon the periodic variations of the cost of labor and material.

The basis upon which the valuation is to be made, having been determined, the engineer is ready to begin the inspection necessary to make the appraisal. In the process of his work it is well for him to keep clearly in mind the particular value to be determined. He must not mechanically collect data, but must familiarize himself with the details of the organization, its history, is operation and its financing relative to the purpose of his search.

Also he must know that the appraisal is being made for the purpose of ascertaining the value of property in its service to the public, and not its junk value. The final figures must be free from all doubt as to their reliability in order that their sponsor can substantiate them when being cross examined on the witness stand.

Bearing these points in mind, the engineer is ready to proceed with the actual examinations of the property. This consists of first making a very thorough inventory and then analyzing the efficiency of operation of the utility.

The success of the entire valuation depends upon the inventory, and hence it is obvious that it must be complete and accurate. In order to minimize the work necessary to complete the report after the field inspection is concluded, certain separation and classification of data is necessary. Machinery, buildings, and construction items are recorded as units so that prices for any period

may be applied in the future , without confusion or unnecessary labor.

The total property value may be considered as consisting of a tangible value, and an intangible value of the property is that represented by the value of its physical property. The intangible value does not represent actual property, but is what sometimes is known as "franchise value," "going concern value," or "good will value." In the process of the valuation, the tangible value of the property is divided into sub classes, such as real estate, buildings, transmission system, distribution system, consumers services, etc. A further clasification of each sub-division may be made as follows: Buildings may be separated into generator station, boiler house, office; the transmission system may be divided into poles, fixtures and overhead conductors; the distribution system into poles and fixtures, overhead conductors, distribution transformers, lightning arresters, etc. The nature of the classification depends upon the location of the property, and also upon the separations made in the accounting room by the company.

In making the inventory each item of property is carefully prescribed, giving the manufacturer's name, the date of installation, its operating condition and its approximate remaining life. Particular mention is made of peculiar conditions of installation which affect the cost thereof, its operating efficiency and its state of maintenance. The inventory is so sectionalized that an inspector's report may later be checked in part for its accuracy without making it necessary to repeat a great amount of previous work. This is an important feature of the inspection, as the field notes may be used as evidence in hearings.

In addition to making a complete inventory it is necessary to obtain from the vouchers of the company and other records, available data as to the costs and conditions under which the property was erected and developed. Further information is ascertained concerning labor and material costs in the particular locality by making inquiries among the contractors, builders, manufacturers and dealers supplying the community in question.

Particular attention is given to the expenditure during the early history of the company involving items of development expenses, such as interest, taxes and similar expenses during coning construction. The issuance of securities and other forms of

indebtedness are ascertained from the record books of the company. Upon concluding the field inspection of the property, and examining its records, the engineer returns to the office to tabulate the results of his work, to which he then applies the unit prices prevailing throughout the particular valuation period. The unit costs applied to the inventory are dependent upon the basis upon which the appraisal is being made, historic cost or reproduction cost. By unit cost of an item is meant the total cost to the utility from the time it leaves the manufacturer until it is installed, comprising selling price, transportation and installation charges. The unit cost thus determined is then applied to the quantities found in the inventory. Allowances for overhead charges, such as engineering, contractor's profit, contingencies, administration or superintendence during construction, are made. These overhead charges may be made on each individual item, but as a rule are applied to certain groups of items.

The summation of the costs of the individual items determined in this manner then give either the historic cost or reproduction value, depending upon the basis upon which the valuation is made. To determine the present value of the property an allowance for its depreciation is made.

Depreciation may occur as the result of the loss of useful life of a plant unit or because of the invention of a more efficient unit or in consequence of a change that makes it more economical to render equivalent service with another plant unit. From this definition it can be seen that the calculation of depreciation becomes difficult because of the widely varying conditions which must be considered.. While certain methods have been developed and some principles widely accepted, nevertheless trustworthy engineering data on depreciation are exceedingly scarce. Two methods have become popular during recent years, namely, the straight line formula and the sinking fund formula.

The former method is based on the assumption that depreciation accrues according to a straight line law in a simple ratio of age to life. The formula used follows:

I = Original investment in dollars.
R = Removal cost in dollars.
S = Salvage value in dollars.
D = Annual depreciation in dollars.
L = Estimated life in years.

A = Age in years.
P = Present worth in dollars.
X = Accrued depreciation.

Then

$$D = \frac{I + R - S}{L}$$

$$X = AD$$

$$P = I - X$$

The sinking fund assumes that the accrued depreciation of a plant unit is the amount already accumulated in a sinking fund that was begun when the plant unit was first put into service and whose annual depreciation is such that compounded at a certain rate of interest the amount at the end of the life of a plant unit will equal the first cost. In addition to the above data let,

Q = Percentage of annual depreciation.
V = $1 + R - S$.
R = A certain rate of interest.

The formulae which may be developed are:

$$Q = \frac{V}{I}\left[\frac{R}{(1-R)^{L-1}}\right]$$

$$X = V\left[\frac{(1-R)^{L-(1-R)A}}{(1-R)^{L-1}}\right]$$

$$P = 1 - X.$$

After the present physical value of the plant is determined a study of the history of the finances should be made with purpose of determining the advisability of allowing intangible values such as development expenses and "going value." Whenever investigations show actual deficit during the early years of the company's operation a "going concern" value can be substantiated. Otherwise it is doubtful whether a regulating body will accept such a figure for "good will," as that in a public utility is synanymous to the franchise right, the cost of which is a slight item.

Thus the total present value of the property becomes the summation of the physical plant value, the development expenses and "going concern" value.

Now let us see how this present value may be utilized in establishing fair rates for the company's service. First, the allowable annual revenue must be determined. That in turn is dependant upon what the regulating body may consider as a fair net profit on the investment, the annual operating expenses, depreciation, and the working capital necessary for an active utility. The following illustration is taken from a recent valuation of an electric company. The reproduction costs established in this particular case were based upon the costs of labor and material for the five year period commencing January 1, 1915, and ending December 31, 1919. This period was chosen because the Public Service Commission approved of it, and also because the majority of the company's property was established during that time. The four per cent sinking fund method of depreciation was used.

Total Reproduction Value	$235,107.54
Annual Depreciation	5,989.46
Accrued Depreciation	53,694.84
Present Physical Value	181,412.70
Contingencies, 5 per cent on all items except real estate	8,405.64
Engineering and Supervision, 5 per cent on certain construction items	8,823.48
Organization, Legal Expense, Insurance, etc., 2 per cent on total	3,972.83
Interest during construction, 15 months, at 6 per cent gives 3.75 per cent on all items except real estate	6,950.32
Real Estate, 6 per cent	1,036.37
Total Present Value	210,601.34
Going Concern Value	12,000.00
Working Capital	8,000.00
Amount for Rate Base	230,601.34

An allowance for working capital is made as an active utility must be in a position to promptly meet all expenses for purchases of material and equipment, for new business and extensions as well as to take care of current maintenance and operating expenses. Since accounts from consumers usually are not paid until the tenth of the month, operating expenses for a month and a quarter are considered as an adequate amount.

The practice of the utility commission in the state in which the valuation was made commonly allows a net profit of 7 per cent on the actual investment, hence:

7 per cent on $230,601.34	$ 16,142.09
Annual Depreciation	6,975.00
Operating Expenses	76,119.95
Non-operating Expenses	45,000.00
Total Annual Revenue Should Be	$144,237.04

The rate schedule was adjusted so that the annual gross revenue amounted to approximately $144,127.00.

The completed report of valuation contains:

A—Description of the property.

B—Explanation of the Method of Valuation.

1—Historic or Reproduction.

2—Explanation of Unit Cost.

3—Method of Depreciation.

4—Field Inspection and Inventory.

5—Application of Percentages for Overhead.

6—Determination of Intangible Values.

C—Analysis of Operating Expenses.

D—Determination of Fair Rate Base.

E—Tables showing itemized inventory and unit costs applied to them.

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DR. FRANK WAKELY GUNSAULUS

Dr. Frank Wakely Gunsaulus, lecturer, author, president of Armour Institute of Technology, and the outstanding minister of Chicago, died at his home March 17, of heart failure. Death came two hours after he was stricken by an early morning attack.

Dr. Gunsaulus was born at Chesterville, Ohio, Jan. 1, 1856, and was a graduate of Ohio Wesleyan University, entering the Methodist ministry shortly after graduation.

He was of Spanish descent, and traced his ancestry to a Protestant martyr killed during the Spanish inquisition in the sixteenth century. He had three charges in Ohio during his four years as a Methodist minister, but in 1879 entered the Congregational church, when he accepted a call to Eastwood Church, Columbus, Ohio. Other pastorates were in Newton, Mass., and Baltimore, Md. In 1887 he went to Chicago as pastor of Plymouth Congregational church.

He was joint founder with the late Philip D. Armour, of the Armour Institute. Following a sermon in which Dr. Gunsaulus spoke of the obligations of the rich towards the poor, Mr. Armour said he would give the money if Dr. Gunsaulus would give the time to carry out

the ideals expressed in the sermon. The result was the establishment of Armour Institute.

In 1899 Dr. Gunsaulus resigned the pastorate of Plymouth Church to become pastor of Central Church, a non-sectarian body, formerly served by David Swing and Newell Dwight Hillis. Plans for the expansion of Armour Institute became so heavy that in 1919 he resigned the pastorate of Central Church and was succeeded by Dr. Frederick F. Shannon.

Dr. Gunsaulus held numerous lectureships in American Universities and colleges. Some of his famous lectures were on Cromwell, Washington, Savanarola, and Gladstone. He was the author of a biography of Gladstone, of a life of Christ, entitled, "The Man of Galilee," and of a number of sermons and poems. He was an intense lover of books. His oratorical gifts were exceptional, and his genius of administration was evidenced by the rapid growth of Armour Institute.

Funeral services were held March 19, in the New England Congregational Church, and were conducted by Dr. Shannon, assisted by Dr. Charles W. Gilkey of the Hyde Park Baptist Church, and Dr. C. F. Brown of the Austin Congregational Church. He is survived by his widow, a son, and four daughters.

—"The Continent," March 24, 1921.

THE CHRISTIAN MINISTER

I hold that the ministry of Doctor Frank W. Gunsaulus in the City of Chicago is without a parallel in American history. A few have equalled him as a preacher; a very select few have surpassed him as a preacher—Beecher and Brooks and Simpson. But not one has sent forth such streams of influence into so many different channels of a great city's life as did this man, for whom

the chariots of God have lately swung low. I say the many-sidedness of his ministry is unparalleled in our annals. As a matter of fact, most of us do well in our desire and determination to do one thing; but it is a source of joy now and then to have a man walk down our human ways, and, through the teeming wealth of his nature, have the very soil of his soul, like the earth in these spring days, ache and heave and stir with many kinds of mental and spiritual fruits and flowers. On hearing of his home-coming, and knowing of his love for children, I quoted the words of Francis Thompson: "Look for me in the nurseries of Heaven." "But," as answered my wife, "you will have to go beyond the nurseries for Doctor Gunsaulus. You will find him among the artists, the musicians, the poets, the orators, the educators, the preachers, and the prophets. He will be everywhere." Was it not a wise reply? The uniqueness of his minstiry required many kinds of earth for the manifestation of his soul while in the flesh; now that he wears his spiritual body, will he not also have to have many kinds of heavenly reality for the utterance of his unfettered self? One of his friends said of the late John Burroughs: "Well, he used to wonder what it was like beyond and I suppose he will begin philosophizing again as soon as he gets his bearings. There will be birds, where John Burroughs is —birds and great trees." *There will be souls where Frank Gunsaulus is—souls and great music.*

A second aspect of his ministry is its rich humanness and genuine democracy. He was an aristocratic democrat—that is, he united the highest culture with the widest human sympathies. He was grandly free from a class consciousness and untoward political partisanship. "I am a Republican," he said to me not long ago, "because I believe in a republic—a representative form of government—rather than in a pure democracy; but oh! how I do hate professional politicians!" Even that holy and righteous hatred was born of his Christian love. I would to God that it might be born in the heart of every min-

ister in America. Then he would not allow the professional politicians to make a fool of him, which is their first step in making a fool of him.

All classes and conditions of humanity found in this minister and minstrel the shadow of a great rock in a weary land. Rich and poor, educated and uneducated, capitalist and laborer, young and old—he was to all as streams of water in a dry place. As chairman of Chicago's Near East Relief Commission, he struggled out of bed, staggered to the telephone, and sent this message: "Use my name in any way you see fit to help in the Near East cause. If we lose Armenia, we lose the gateway. Do not thank me; it is my duty." Fighting his valiant fight with death, and having already received his death-wound, this was among the very last of his eloquent pleas for a broken and bleeding humanity.

FREDERICK F. SHANNON.

THE ARTIST

To one who desired to increase his realization of the beautiful Dr. Gunsaulus came bearing gifts. Unlike the critic who concerns himself only with the differentiation of the arts, unlike the analyst, who offers us his own kind of esthetic pleasure in leaving us to wonder at the beauty of the inarticulate parts which he has disjointed, the Doctor's was a peculiar mission. He made the enjoyment of art three dimensional. With him literature, history, the scripture, psychology, each became in turn a vantage point from which the work of art presented itself with a new glory or with additional significance. And in his hands the work itself became like a torch sending out its rays to illuminate all manner of corners and crevices of human interest. Surely the nine muses must have loved an art lover of this kind, for he never failed in his devotion to each of them. And if the muses can be thought of as interesting themselves in the service of mankind, it would seem that Dr. Gunsaulus really carried out their inten-

tions. He more than anyone else in this community has opened the doors of esthetic enjoyment to the passing layman. His flame-like appreciation has kindled many a nature which without him would have remained unwarmed by the genial fire of the beautiful.

George William Eggers.

THE SCHOLAR

The personality of Dr. Gunsaulus was complex and manysided. He was not only a great preacher and lecturer, but also a poet, an educator, an interpreter of art, and last but not least a scholar. Indeed he remarked to me a number of times that the great desire of his life had been to lead the life of a scholar and that he had often regretted that other interests and demands had called him away from his favorite pursuit.

During the early years of his career as a minitser Doctor Gunsaulus spent much time in study. He collected a wonderful library, covering especially the fields of literature, history, and biography. He often told me how in those earlier years he had spent the small sums he had received for lecturing upon purchasing his favorite books. It is not generally known that his wonderful collection was purchased from him by Mr. P. D. Armour after his breakdown in 1898 to help him defray the expenses of his illness and that they are now a part of our Armour Institute Library. I remember his speaking of the fact that now and then men would remark that he had been greatly favored by fortunate circumstances and how he would remind them of those early years when he had laid the foundations of his remarkable career by faithful digging and plodding. Later on he had little time for systematic study but was able to draw upon the vast stores he accumulated in his early manhood.

His learning was broad rather than deep. Nature had endowed him with such marvelous gifts that he might

have become as great a scholar as some of the greatest German and English theologians, such as Harnack, Frederick Robertson Smith, Lightfoot, or Westcott. He had a marvelous memory. A mere glance at a printed page was sufficient to imprint its contents upon his mind. I have never met a man who had such power of intuition. You needed only to faintly suggest a line of thought and he had like a flsh of lightning fathomed all its bearings. He had such broad, catholic interests that nothing human was foreign to him. He always went straight to the heart of every question. Dry-as-dust learning was repulsive to him. He loved to attack narrow prejudices. In history and literature his reading was very comprehensive. He cared little for fiction but in the great masterpieces of thought he was thoroughly at home.

By George Lawrence Scherger.
Professor of History and Political Science, Armour Institute.

THE FRIEND

"I had a friend."

What a world of tenderness that phrase unfolds, as memory turns the scroll of years, filled with the acts of unselfishness, kindness, and of love, by Frank W. Gunsaulus.

A generation ago he came into our lives, not as a benediction, but as a revolution.

In me and mine he stirred aspirations and desires before then dormant.

He knew, and he gave to us the desire to know also.

At thirty-one, five years my junior, he came a Prince of Light.

Just recently through college training, and with a retentive memory he had packed away wisdom from all the past, and this he gave us freely.

Not as the pedant does, but as though it was our thought he had acquired, and was simply using for our benefit.

How unselfish he was with all he had, time, talent, possessions.

Books he brought, and music, poetry, tales, and on each poured the wealth of his knowledge, experience and understanding, so that they flamed into divine fires.

If any trouble brewed, he discerned it and came to help.

Like all great natures, he had his own heights and depths of feeling, and many nights we tramped the city streets conferring together on his trouble or mine, until the clouds broke, and his sense of humor cleared the air that had been oppressive, and we parted with a new and closer sense of kinship.

Upon inquiring more than once why he wore old clothes, the response was "A clerical brother down state needed the others to maintain his dignity."

Picture if you can a tall, alert, witty man, the very epitome of enthusiasm, filled with eloquence, with learning, and with song, telling us in the pulpit hour of the joys of friendship, and then privileged to walk home with him, to taste its sweetness.

To his friendship and interest, we feel we owe all that is best in life, and great as he was, he was simple in taste, kindly, thoughtful, and with no bitterness in his nature.

And how we loved and admired him. Great as he was in intellect and learning, touched by the divine fire of Genius, his heart was built in even a larger mould, and in it we feel we had a secure place.

FRANK E. LOGAN.

THE MAN.

Aside from the Church, School, Lecture Platform, Art Gallery, and Museum, where he shone with such splendor, Dr. Gunsaulus excelled in a large way in all the attributes of a kindly and helpful neighbor, a sympathetic and affectionate companion and a wise and thoughtful counselor. He was easily approachable and his genial countenance was an invitation to everyone to come to him. He was

probably known to and had spoken with as large a number of people as any man among us, excepting perhaps, Col. Roosevelt, and that other great Commoner, Mr. Bryan.

Dr. Gunsaulus had a particular knack of getting acquainted with people who were in trouble: They interested him greatly, and incidentally kept him poor, for he gave with lavish hand.

He added tremendously to the welfare and happiness of the world by his own work, and even more was added by others through his example and urging. His gracious and generous expressions of appreciation and approval were a sure and prompt reward for every effort. He had a long memory for our graces and a merciful forgetfulness for our shortcomings.

He was an optimist. In this tattered and torn world of ours any kind of an optimist is worth while, but there are variations in values of optimists. We have the fixed optimist who is serene and placid and is sure that everything will come out right and does not move to help; and we have the fighting optimist, of which Dr. Gunsaulus was a brilliant example, who far from sure that we can succeed, throws his whole soul and strength into the combat, eats little, sleeps little, worries and works valiantly until the battle is won..

Dr. Gunsaulus could have added to his many accomplishments had there been more months in the year and more years in one man's life. A lover of God, he loved all of His Creations and if on rare occasions he had to say he "didn't know," it was with a look and tone of regret, as though he had been lacking.

By B. E. Sunny,
President Bell Telephone Co.

O CAPTAIN! MY CAPTAIN!

O Captain! my Captain! our fearful trip is done,
The ship has weather'd every rack, the prize we sought is won.
The port is near, the bells I hear, the people all exulting,
While follow eyes the steady keel, the vessel grim and daring;

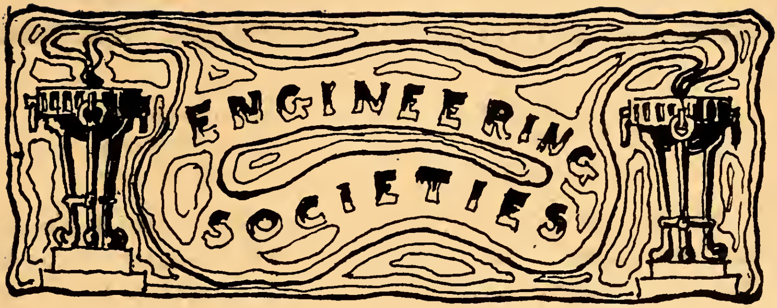
But O heart! heart! heart!
O the bleeding drops of red,
Where on the deck my Captain lies,
Fallen cold and dead.

O Captain! my Captain! rise up and hear the bells;
Rise up—for you the flag is flung—for you the bugle trills,
For you bouquets and ribbon'd wreaths—for you the shores a-crowding,
For you they call the swaying mass, their eager faces turning;

Hear Captain! dear father!
This arm beneath your head!
It is some dream that on the deck,
You've fallen cold and dead.

My Captain does not answer, his lips are pale and still,
My father does not feel my arm, he has no pulse nor will,
The ship is anchor'd safe and sound, its voyage closed and done,
From fearful trip the victor ship comes in with object won;

Exult O shores, and ring O bells!
But I with mournful tread,
Walk the deck my Captain lies,
Fallen cold and dead. —By Walt Whitman.



THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Prof. G. F. Gebhardt ....Honorary Chairman
Charles T. Walter ....President
John P. Sanger .... Vice-President
Robt. W. Van Valzah ....Treasurer
William A. Heitner ....Secretary

The last meeting of the A. S. M. E. was held on March 23, 1921. Mr. Bradbury gave a very interesting talk in which some of the factors justifying the "Special Theory of Relativity" were considered. The equations for the "Lorentz Transformation," and for the addition of velocities were developed. The aspects of the "General Theory" were also outlined in an elementary way. Mr. Bradbury's excellent manner of address fully justified the large audience he drew, which consisted of representatives of all the Engineering Societies of the Institute.

This year has been the most successful one for the A. S. M. E. since the period of the war. This was largely due to the rigid adherence to the program adopted at the initial meeting.

The enthusiastic manner in which the Juniors participated in the talks throughout the year predicts a very bright outlook for next year.

W. A. Heitner, Secretary.

ARMOUR INSTITUTE OF TECHNOLOGY BRANCH AMERICAN INSTITUTION OF ELECTRICAL ENGINEERS

R. C. Malwitz .... Chairman
T. L. Albee .... Secretary
W. W. Pearce .... Treasurer

The past year has certainly been a most successful one for the local branch of the A. I. E. E. With the one exception of the First Smoker, when a speaker failed to appear, every plan has been carried out with good results. Every meeting has been well attended, and in every instance the audience has been well repaid.

The American Institute of Electrical Engineers, in providing for Branches such as this at Armour, has made it the main purpose of these organizations to give students a broader view of engineering work, and at the same time, to acquaint them with the problems of moment and the men who solve them. Contact with a national organization is the chief source of benefits along this line, and this is furnished by speakers at local meetings, by meetings with the Chicago Section, and by the published Proceedings of the Institute. Ranking with these in importance is the training of the student members in speaking. A feature of the meetings of the past year has been the remarkably able talks by the Branch members, a large number of whom have spent considerable time and trouble in preparing papers, for which work they are to be sincerely thanked.

Professor Freeman and Professor Snow have put the Armour Branch under deep obligations by their interest and assistance thruout the year. Professor Freeman's talk on Character, given at the first Smoker, was one of the features of the year, and Professor Snow's paper on "Substations," presented at the meeting of April 7, 1921, was equally valuable in its line. The information concerning the design and construction of substations was greatly appreciated, especially by the Seniors.

The A. I. E. E. Smoker, held Feb. 25, was such a success in every way, and was so thoroughly enjoyed by all attending, that similar get-together meetings were immediately planned for later dates. One of these was held on April 22, which satisfied all expectations. The last meeting of the year will be held early in

May, for the election of officers for the year 1921-1922. This meeting will bring to a close one of the best seasons that the Armour Institute Branch of the A. I. E. E. has known since its founding in 1903.

T. L. Albee, Secretary.

WESTERN SOCIETY OF ENGINEERS

Since the report in the last "Engineer" the Armour Branch of the Western Society of Engineers has held three meetings. At the first of these election of officers was held with the results as follows:

President	R. F. Campbell
Vice-President	H. A. Peterson
Treasurer	T. Michels
Secretary	E. M. Seaberg
Ass't. Sec'y.	V. Hamacek
Faculty Member, Board of Managers	Prof. M. B. Wells

At the next meeting talks were given by the retiring and incoming presidents. Retiring President Singer talked on the subject, "A Cultural Education versus a Technical Education." His attempt to prove mathematically that the former was the more valuable was somewhat too involved for the most of us, but his views were interesting and appreciated.

Mr. Campbell, the incoming president, then made a few remarks on the status of the engineer in the British Empire and the United States, followed by some suggestions from Prof. Wells.

At our last meeting, Mr. F. D. Avery, Bridge Maintenance Engineer for the City of Chicago, gave a very interesting illustratel lecture on his work in connection with the bridges of this city. His ideas were interesting and should have proved valuable, for he emphasized the fact that the maintenance of any structure is too often forgotten during design. Although his views of vertical shear undoubtedly startled us, our ideas concerning the stopping of traffic while a bridge is being raised were broadened and our appreciation of other difficulties of his position increased.

The attendance at this meeting was very good and the indications are that the year before us is to be one of progress for our organization.

E. M. Seaberg.

ARMOUR CHEMICAL ENGINEERING SOCIETY

President ....Emil F. Winter
Vice-Pres. ....J. W. McCaffrey
Secretary ....W. J. Savoye
Treasurer ....H. W. Ahlbeck

The A. Ch. E. S. held one of the old-time live-wire meetings on Tuesday, April 12, 1921. It was a smoker held in the Y. M. C. A. rooms of Chapin Hall and was well attended by alumni, faculty and students. Many talks of interest on various subjects of the chemical field were given by the alumni which proved to be both instructive and entertaining. This being a very informal and more or less sociable meeting, it was enjoyed to the fullest extent by all. When the doughnuts and cider were served it seemed as though all the students were in a food analysis class.

It is hoped that another meeting of this type can be arranged for, in the latter part of April and this, together with a farewell banquet that is being planned for May will conclude the activities of the Society for this year.

We thank the entertainment committee, the alumni and the faculty for the interest shown in the society.

ARMOUR RADIO ASSOCIATION

E. A. Goodnow ....President
G. H. Kelley ....Vice-President
H. I. Hultgren ....Chief Operator
R. S. Kenrick ....Sec'y.-Treas.

As conclusive evidence of the stimulus given to radio by the Armour Radio Association it may be stated that the membership has steadily increased from twelve at the beginning of the year up to twenty-two at the present writing. Such a phenomenal increase in membership has never been duplicated in the history of the asociation. The attendance at the meetings has been satisfactory and the Sophomores have shown an interest in radio which we hope can be encouraged.

At the eighth regular meeting, held in the Physics Lecture Room, on March 9, 1921, the chief business before the associa-

tion was the election of a new vice-president to fill the vacancy created by the absence of L. V. Cooley who has left school. Mr. George H. Kelley was unanimously elected to this office by the quorum of members present.

On March 4, 1921 the radio men at the Institute decided that they would make a big news scoop by copying President Harding's inaugural address by radio, using the receiving station at the Institute. Typewritten bulletins were to be pasted upon the bulletin board as sections of the address came in "hot off the ether." The two most competent operators in the association (Chief Operator Hultgren and A. R. Mehrhof) were delegated to don the head pieces and translate the "ethereal Greek." Promptly at 11:00 A. M. (Central Time) the big transatlantic station at Tuckerton N. J. (WGG) began calling the famous German station at Nauen, stating that it had a message for the press correspondent located at a certain hotel in Berlin. The operator at Tuckerton then proceeded with the President's inaugural address. He was kind enough to state that "all interested may copy," although he neglected to state how he could prevent any one from copying the message if they so desired. The big surprise came, however, when someone rushed in the room with an early afternoon edition of a local paper, containing the entire address of the President, whereas up to that moment only a meagre fraction had been received via radio. It finally dawned upon us that the newspapers had received copies of the presidential address several days before publication and then released the news at the proper time. The novelty "scoop" was completely lost and some of the men were inclined to be bitter toward the newspaper men because of their enterprising tactics.

The Association now boasts an efficient continuous-wave transmitter in place of the old spark set which was completed a year ago. The "nerve center" of the new transmitter is a Type P General Electric Pliatron vacuum tube. The plate potential for this power tube is furnished by a 1500 volt D. C. Crocker-Wheeler motor-generator set. The maximum radiation is about 2.5 amperes at a wave length of 345 meters. The reports on reception of our new station have been very favorable, many replying that our signals have been "very QSA".

The Association will also soon be able to boast of an efficient radio telephone transmitter as the result of the labors of one of

our members, W. W. Pearce, who is working upon this new station as a subject for his senior thesis.

Both long and short wave receiving sets are now in satisfactory operation, having a receiving radius of over three thousand miles.

The radio fraternity at Armour has nearly completed another year of progress and activity; much has been done but more remains to be done and it is up to the members next fall to carry on this interesting work.

Ralph Kenrick, Secretary.

GOOD SCHOLARSHIP IN COLLEGE AND EMINENCE IN ENGINEERING

A close correspondence between good scholarship in college and eminence in engineering is shown in an investigation made under the auspices of the American Association of Collegiate Registrars by Prof. Raymond Walters of Lehigh University who presents a report in the current issue of "School and Society." It was found that of 392 distinguished engineers graduated at 75 technical schools, 182 or 46.4 per cent, stood in the highest fifth of their class scholastically upon graduation, 109 or 27.8 per cent stood in the second highest fifth, 72 or 18.3 per cent in the middle fifth, 14 or 3.6 per cent in the next to lowest fifth, and 15 or 3.8 per cent in the lowest fifth. Figures for a group of 189 alumni of five eastern engineering schools were somewhat different in the upper classes, the second highest scholastic fifth having the largest percentage. In all groupings of the eminent engineers there were less than 4 per cent in each of the two lowest scholastic fifths. Of 730 names on the Registrar's Association list of distinguished engineers, practically 80 per cent were found to be collegiate graduates, 16 per cent men of secondary school education, and less than 5 per cent men who started in college but did not finish. The arbitrary basis of eminence in this study of a professional group was taken to be the holding of office, membership, in important committees, and service as representatives of the four "founder" engineering societies, civil, mechanical, electrical, and mining and metallurgy, for five years, 1915-1919. —Engineering and Contracting, 3-16-21.

COLLEGE NOTES

DEAN RAYMOND ACTING PRESIDENT

On Monday, March 27, an assembly was held in the Armour Mission. Here Mr. George S. Allison, secretary to the Board of Trustees, read a letter from the Board appointing Dean H. M. Raymond Acting President of the Institute for the remainder of the college year. The announcement was greeted with much applause. Dean Raymond then spoke of the problems confronting the Institute, and of the spirit in which they must be met. Dean Monin spoke for the student body and for the faculty, assuring Dean Raymond of the hearty support and cooperation of all.

GRADUATION EXERCISES

The Senior Class announces that the Baccalaureate Sermon will be delivered Sunday, May 29th, at Central Church, 220 S. Michigan Ave., by Dr. Frederick F. Shannon.

The Commencement Exercises will be held in the Armour Mission on Thursday evening, June 2nd. Dr. John Timothy Stone, pastor of the Fourth Presbyterian Church, Chicago, will deliver the commencement address. His subject will be "Operation and Cooperation."

All students and their friends are cordially invited to attend these exercises.

NO THESES IN 1922

At a meeting of the Executive Council and the heads of the departments, it was decided to do away with the undergraduate theses, beginning with 1922. This work will be supplemented by special experimental problems requiring the same amount of time as formerly devoted to thesis work.

SENIOR THESES IN CIVIL ENGINEERING

EDWARD MUNDT
Sand and Gravel Washing Plants.

WILLIAM K. LYON, Jr.

GEORGE W. PETERSON
Comparative Designs of the Gravity and Ambursen Dams.

HERBERT A. MANN
History of the Development of the Suspension Cable Bridge.

DERWOOD CHASE
Study of the Building Problems of the Badger Basket Company of Burlington, Iowa.

SIDNEY J. BURKE
Design of a Reinforced Concrete Chimney.

LEE H. ROSBACK
Design of a Sewer and Water System for Kimberly, Wisconsin.

ROY M. SINGER
Effect of Quantity of Water on the Strength of Various Portland Cement Mortars.

ABRAHAM APPLEBAUM
Secondary Stresses in a 112 foot Pony Truss.

EUGENE M. MATSON
Adaptability of Reinforced Concrete for Oil Storage Purposes, and the Design of a Reinforced Concrete Oil Storage Tank.

ALUMNI NOTES

A meeting of the Officers and Board of Governors of the Alumni Association was held on Friday, March 22, at the Great Northern Grill. At this meeting W. D. Matthews, R. B. Harris, and W. S. Oberfelder were appointed to draw up a set of resolutions to be sent to the family of our late president, Dr. Frank W. Gunsaulus. These men met the following day and prepared and sent the resolutions.

A committee consisting of W. D. Matthews, A. S. Alschuler, R. M. Henderson, F. S. Heuchling, C. T. Malcolmson, and B. S. Carr was appointed to make plans for a permanent memorial for Dr. Gunsaulus. These plans will be ready for presentation to the Alumni Association at its spring meeting in May.

W. A. Kellner, E. H. Freeman, and L. E. Davies were appointed to make arrangements for the spring banquet, and E. O. Griffenhagen, F. M. DeBeers, A. H. Goodhue, L. W. Bunge, and R. O. Joslyn were appointed as a nominating committee.

NEW ADDRESSES

Harry G. Dekker, 09, has been appointed an instructor in chemistry at Calvin College, Grand Rapids, Mich.

Frederick L. Brewer, Jr., '15, is now sales engineer with the Paine, Webber Co., Rookery Bldg. Chicago.

Raymond O. Joslyn and Marcus C. Veremis, both of '19, who upon graduation went to the General Electric Co. at Schenectady, N. Y., have returned and are working in the Chicago offices of the same company.

J. Irving Prest, '18, has returned to Chicago from Seattle, and is now located at the McCormick Works of the International Harvester Co.

Dan M. Stump, '13, is factory superintendent for the Ad Photoscope Co. of Chicago.

Orville C. Badger, '13, is now engineer in the Bridge Department of the A. T. & S. F. Ry. in Chicago.

G. F. Wetzel, '15, has left the F. S. Betz Co. to become Production Engineer in the Factory Division of Montgomery Ward & Co.

Bela de Remanoczy, '19, has returned to Chicago after spending some time in Budapest, Hungary.

Herbert W. Martin, '10, formerly with the Dunbar Mfg. Co., has been made manager of the Engineering Dept. of the V. G. Trueblood Co., Chicago.

OBITUARY

Theodore C. Oehne, '08—Deceased.

ODE TO EFFICIENCY

You were the type of man of which
The present offers all too few.
You thrust aside rewards more rich
To do the work you chose to do.
Your palm had not the golden itch;
There was no dollar-mark on you.

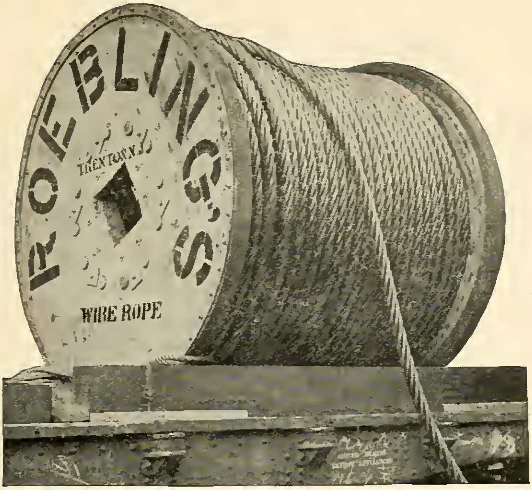
You laid your course, and held it true,
Nor followed any narrow plan.
You held this working world in view.
Yet kept a little in the van.
And any one who knew you knew
You were the measure of a man.

Your brain was clear, your brow was calm,
You planned your work, and kept your course.
You met men with a comrade's palm;
Your heart and hand knew no divorce.
In you there was a sort of balm,
A power rather than a force.

You flew your flag for those who drown,
You fought the undertow beneath;
You sought the service, not the crown;
You earned, but never asked, the wreath.
And when the last wave beat you down,
You gripped your colors in your teeth.

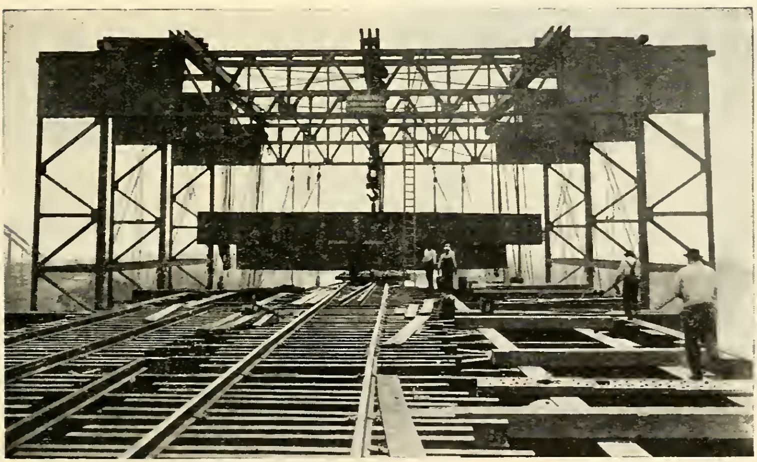
EDMUND VANCE COOKE.

ALPHABETICAL INDEX OF ADVERTISERS.



ROEBLING WIRE ROPE

FOR ENGINEERING



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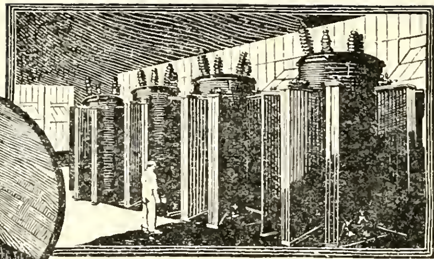

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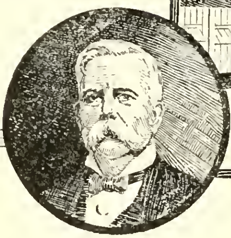
the founder of the
Westinghouse industries



The Vision of This Man

Gave America Alternating Current

Thirty-odd years ago state legislatures were being importuned to prohibit the distribution of alternating current on the pretense that it was dangerous. Today legislatures are asked only to compel its makers to distribute it more widely and sell it more cheaply.

Times have changed since Westinghouse bought the Gaulard and Gibbs Transformer patents, and brought Alternating Current to America. This was the necessary preliminary step to the tremendous developments that Alternating Current, once known as "Westinghouse Current," has made possible.

To eliminate all the alternating systems and apparatus that are in use everywhere today would set this country back thirty years; but there was a time when all the resources and courage that Westinghouse could command were required to withstand the bitter opposition of those who fostered direct current instead. The whole Electrical Industry now recognizes that there is a proper field for each system, but it was all or nothing in the late '80's, when the question was first raised.

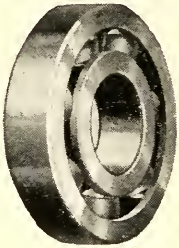
The original alternating current system was hardly practicable, even for lighting purposes. From it, however, have resulted all the modern applications of the alternating current system, the many methods and devices for transmitting current at high voltages and stepping it down to lower pressures by transformers located in connection with the consuming apparatus, whether in the home, in industry, or for the Public Service.

The foresight, the engineering genius, and the courage of Westinghouse fathered the evolution of Alternating Current, one of the greatest modern commodities.

Westinghouse

WESTINGHOUSE ELECTRIC

Correct Bearing Design



In the design of a radial ball bearing race contour, race depth, and the method of introducing the balls between the two rings and the number and size of balls, largely determine the service the bearing will give.

Long experience has taught that the most efficient bearing has a race groove radius equal to 52% of the ball diameter combined with a race depth commensurate with the size of the ball providing necessary capacity.

The consideration of these factors in connection with a high quality of material and skilled workmanship has enabled us to make radial bearings which will safely carry a great load for a long period of time.

Much useful bearing information is contained in these special pamphlets: Lubrication of Ball Bearings; Limits and Allowances on Shafts and Housings; Calculating Bearing Loads; Interchangeable sizes of Strom Bearings.

Write for them

The U. S. Ball Bearing Mfg. Company

(Conrad Patent Licensee)

4560 Palmer Street, Chicago, Ill.

Strom BEARINGS

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Sworn to and subscribed before me this 14th day of March, 1921.

GEORGE S. ALLISON,
Notary Public.

Chicago, March 14, 1921.
(Notary Seal)